School Science and Mathematics

Vol. V. No. 3 CHICAGO, MARCH, 1905 WHOLE No. 32

MOVEMENTS IN MATHEMATICAL TEACHING.*

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It is now nearly a year and a half since Professor Moore gave his presidential address before the American Mathematical Society, an address provoking so much criticism that it is well to consider its results here in the East. It was a fact apparent to all who heard it that the address was not favorably received by many of those present. Whatever opinions may have been publicly expressed, in private there were two adverse criticisms, (1) that a man who stood among the few recognized leaders in higher mathematics in this country should lose the opportunity offered to consider the great problems of the science *per se,* and (2) that one whose field had been so peculiarly one of research should assume to enter the realm of education and to criticise existing methods.

These being the opinions of that time, it was quite apparent that the address would probably have much influence, since the ordinary paper that is pleasantly received is usually consigned to oblivion as speedily as possible. Such has proved to be the case. Either prompted or encouraged by the address, the teachers of mathematics in New England at once organized an association that has undertaken much serious and valuable work in the line of secondary education. Its members are the leaders in that section of the country, and they represent all kinds of schools, public and private, from the elementary grades through the university. Following closely upon that movement, a similar organization was formed in the Middle States and Maryland and has now been actively engaged in work for a year. Contemporary with the formation of the latter association, a conference was

*The manuscript of this article was received February, 1904.

called at the Boston meeting of the National Educational Association, at which the question of the improvement of mathematical teaching was discussed, together with that of the organization of associations similar to those in New England and the Middle States, and steps were taken looking to such results. Meantime the Middle States movement had begun to develop into a plan for local sections similar to those of the American Mathematical Society, and already two such sections have been organized, one at New York and the other at Philadelphia.

Such are some of the results of Professor Moore's paper in the way of organizations. Of the work that will be done it is rather early to speak, but the character of the promoters is such as to assume that it will be serious and progressive. Certain it is that the results of the presidential address have been such as to abundantly justify the assertion of some of the minority of those who heard it, that it would much more epoch-making than most of its predecessors.

It is not, however, too early to estimate the sentiment of the East as to the attitude that this section of the country will take in relation to what has been called the Laboratory Method. Many of the leaders have discussed the question, and in no instance have I seen any desire to consider it in any manner that was not serious and dignified. There has been an earnest effort to understand it, to weigh its merits and its defects, and to adopt that which appeals to the East as usable. But after attending numerous meetings and conferences in which the matter has been carefully considered, I feel convinced that the East will encourage the Central States to continue their experimentation, but will be slow to adopt the extreme views often expressed in that part of the country. Nor is this because the East is content to stagnate and prefers to be let alone. It is true that conservatism has here its American habitat, but the attitude concerning the Laboratory Method arises neither from this feeling nor from ignorance; it comes from a knowledge of what the East demands that other sections do not, and from a conviction that it is not feasible to go to the extreme to which certain parts of the West have gone.

In general, the views of Eastern teachers of the highest rank seem to include the following details as to the question in hand:

1. Any effort to introduce physical experiments to any extent into the classes in mathematics has no support whatever, from

either the teachers of mathematics or those of physics. The testimony of men of highest rank in secondary education, open-minded and practical men who have seriously tried the experiment for sufficient lengths of time, men who are working in schools where conditions were favorable, has been unanimously opposed to the plan.

2. Any effort to seek the applications of mathematics chiefly in physics, or in science generally, has not met with favor, and is not likely to find advocates. The consensus of opinion is that the number of applications of algebra to physics, for example, is exceedingly small, those to business problems being considerably larger, even though these are not numerous. A serious effort is being made in numerous instances to find every genuine application of secondary mathematics, but the feeling is generally expressed that there is as much danger of forced, uninteresting, abstract applications in certain of the physical problems proposed as in many of the inheritances against which we all protest.

3. The attempt to have algebra and geometry appear to the pupil as subjects having any considerable application to science or to business aside from a few special propositions, will not be made. To arouse an interest in these sciences, applications will be sought in every direction and the genuine ones will be used, the game element will be made prominent, and the taste for discovery will be fostered at every step, but the East will use all this as a crutch to get the pupil to walk in the domain of pure mathematics. This is the domain that interests this section of the country, this is the work that our elaborate system of rigid entrance examination demands, and here is the field for improvement of education that strikes the Eastern leaders. How shall we bring our pupils to love mathematics for its own sake, to be discoverers themselves, to look into methods of attack, and to appreciate the elaborate interrelations of propositions, topics, subjects?—this is the great question that attracts our teachers. If some physical problem will assist, well and good, but this is a mere incident; that no equation shall be given without a genuine application, that no problem shall be assigned without physical content, that no topic shall be considered save as it bears upon life—to all this there is bound to be a negative response.

4. There is, however, one phase of laboratory work that is being seriously considered by some of our leaders, men who feel

that this is the essential good of the plan and that it has been obscured by relatively unimportant details. It is that the class room should be a workshop, not in applied but in pure mathematics. This, of course, means that we are to see how much of the spirit of a German gymnasium mathematical class can be transplanted into our schools. A workshop, with the tools of pure mathematics, with the pupils busily at work, with the teacher encouraging and directing, with part of the hour given to rapid, intensive discovery, and the rest to reports (recitations, if you please)—such a picture is in the minds of many with whom I have talked, and who have seen the German system in its own home. Whether the time will come when the recitation hour can be lengthened enough for such work, whether the school day in our cities will admit of such change as to allow most of the studying to be done in the class room, is a serious question. The trouble, from our standpoint, is that the argument for mathematics holds equally well for other subjects, and the problem thus becomes exceedingly complicated. But this phase of genuine laboratory work appeals to many teachers, and the fact that it is recognized is hopeful.

5. The fact that the college entrance examination plays a much more important part in the East than in other sections of country has led to some question as to the attitude of our schools to the movement. But this has not been considered a serious matter. It is increasingly noticeable that the examinations demand power rather than the memorizing of facts, and hence the best system of teaching is the one that will carry the day.

In conclusion, the feeling in the East, as I interpret it after much study, is one of earnest desire to make the class in mathematics a workshop, but in the high school it must be a workshop in pure mathematics. In arithmetic, where the field of real application is very large, there is a manifest desire to banish those problems that pretend to relate to business and science, but do not do so, to substitute genuine ones in their stead, but to hold to such an amount of abstract work as to bring that mechanical efficiency that is necessary to fairly rapid and accurate computation. In algebra and geometry, where the field of real applications is very small, the chief effort will be to turn the class into a laboratory in pure mathematics, recognizing that the applied

problem shall be used as one of several means for arousing interest, but that this is a mere incident.

To the Western mind this may seem a conservative position. Those of us in the East who have lived in the West long enough to acquire some of the spirit of that section appreciate this feeling. But the above statement represents not merely what is the present attitude of the East, but what is the probable future attitude on this matter.

In this section the attitude is felt to be the judicial one, and it is probable that in the Central States there will be found many who think that it is such. But of the good results arising from Professor Moore's paper there are few teachers of mathematics who can doubt. It set the East thinking, and while the East thinks slowly it thinks judicially, while it works conservatively it works thoroughly, while it is not given to rash experiment it is not blind to results, and while it is influenced by traditions it is ready to change when it sees other plans proved to be better then its own.

SOME PROBLEMS CONFRONTING THE TEACHERS OF GEOMETRY.*

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The longer I teach geometry the more am I convinced that comprehension of the subject is a slow growth. Students come to us at the beginning of the second year of high school. In too many schools their previous training has been mere drill on forms. Problems in arithmetic and algebra have too largely been drill for the sake of passing examinations. In other words, the students have not been taught to think. A subject is before them that is new in its language, form, method and substance. The student must be taught this language and these forms, and he must be taught to think, and to think logically. Formal drill must be abandoned and the mind's machinery must be set in motion, and to many the effect is a strange awakening. Just here is where the inexperienced teacher fails and the student, instead of loving

* Address given before the Mathematics Section, C. A. S. and M. T., November 25, 1904.

the geometry, grows to hate it. In the beginning progress must be slow and painstaking, the subject matter gradually unfolding day by day until the beginner's foundations are sure and steadfast.

First of all, the student must be taught to love the subject—interest must be maintained. To this end one must encourage and censure sparingly. William Spencer says: "The inventive power grows best in the sunshine of encouragement. Its first shoots are tender. Upbraiding a pupil with his want of skill acts like a frost upon it and materially checks its growth." One good way to maintain this interest is to give students a notion of the origin and development of the subject being studied. Again, where propositions are studied that are of historical interest, point out by whom and how they were discovered. Have some one look up the life of the discoverer and make a brief report to the class. Show students the high estimate put upon geometry by ancient mathematicians.

All students, whether mathematically inclined or not, should study geometry. Why? No other subject equals it for developing and strengthening the reasoning powers. Its study leads to a correct use of language. Some one has said, "Language is not an original process and does not exist for its own sake, but it is only a vehicle to convey the precious burden of thought. Clear thinking will compel clear utterance." "To say something well, teach well something to say." The study of geometry trains the rational memory. Thought-processes are here logical, and gradually logical habits becomes fixed and extend to all the experiences of life. In short, we shall sometime do all our thinking in this manner.

A problem that confronts the teacher very early is when and where shall abridgement come? Knowing that the young people are flesh and blood, oftentimes with an abundant supply of nerves, and that much work is not only expected, but required of high school students, we must prune generously, refraining only from working injury to the student's future work. We must meet the requirements and the expectations of colleges and universities. I think we shall agree that the value arising from the study of geometry is twofold, practical and cultural. The early Egyptians studied it for its practical value; the Greeks, for its cultural value. All geometry has a cultural value for all students, but not all has

a practical value. I would omit the "culture for culture's sake" and concern myself principally with practical geometry.

We cannot afford to eliminate any theorem from Book I. We need this Book entire for future work. While I do not omit them, we might well omit without loss the two theorems, "If two chords intersect each other, the line of centres is perpendicular," etc., and "If two circles are tangent to each other the line of centres passes through the point of contact."

The bisector of the interior angle and of the exterior angle of the triangle are of value to the student of projective geometry, inasmuch as they acquaint him with the idea of a line harmonically divided. Again, through these propositions we fix the idea of segments of a line. Still they may be omitted without loss to the average student.

"If two parallels are cut by three or more transversals that pass through the same point, the corresponding segments are proportional and conversely," should be omitted. It does not relate to any subsequent proposition. I would omit, "The sum of the squares of two sides of a triangle is equal to twice the square of half the third side, etc.; the difference of the squares, etc.; the square of the bisector of an angle of a triangle, etc., and, in any triangle the product of two sides is equal to the product of the diameter," etc.

Another problem that confronts the teacher of geometry is, when shall the so-called originals be introduced and how much time shall be spent with them?

It is a sad fact that in many schools the originals are ignored altogether. In some they are left till the end of the course; in others, they are worked in co-ordination with the theorems bearing upon the same topic, or after the theorems of a topic have been proved the originals bearing upon these are worked. The latter plan I consider preferable. When the subject matter is completed to triangles in Wentworth's or a similar book, the class should complete all the originals on the subject of oblique, parallel and perpendicular lines. When the topic of triangles is completed, nearly all, if not all of the originals of triangles should be completed. I think all teachers of geometry will agree to this.

When the student has completed the theory of parallel lines, perpendicular lines, the definitions of triangles, the equality of triangles, let each one make a table similar to the following:

Angles are equal, (a) when they may be made to coincide; (b) when supplements of the same or of equal angles; (c) when complements of the same or of equal angles; (d) when two parallel lines are cut by a transversal, the alternate interior, etc., are equal; (e) when homologous angles of equal triangles. So let pupils make a table for the equality of lines. Show them that in a majority of the cases in originals they will prove lines and angles equal by homologous parts of equal triangles. Then let them prepare a list for the parallelism of lines. Show them in a majority of cases that the lines will be parallel because certain pairs of angles which they make with a transversal are equal, and, in a majority of cases, these angles are equal because they are homologous angles of equal triangles. Thus it is seen that the two problems are closely related. When we consider that most of the theory of quadrilaterals, as well as most of their originals, are concerned in this problem, we understand how essential it is that the student thoroughly comprehend it. To cope successfully with originals the student must have at his command sufficient data; then through analysis he must be able by practice to ascertain his problem and how it is related to the great body of geometric truths. He must reason back from the particular to the general and when he has discovered, analytically, what he is to do and how, then he is able to give the synthetic proof of it. Students grow to love the original work and very soon the majority prefer it to the theorems proved in the text.

How much shall be done with originals? I believe a class can work to advantage nearly all of those found in Book I., about twenty-five in Book II., with as many, or more of the original problems of construction, and in Books III., IV. and V., but *very* few.

Another problem for the teacher of geometry is, shall the construction of figures be taught from the beginning, or later in the course? In many text-books the problems of construction are grouped and taught after developing the subject matter pertaining to them. To illustrate, the student has bisected the angle, drawn the perpendicular, constructed the angle equal to a given angle, etc., many times, free-hand, before he learns anything about how it is done geometrically. This is according to the old law, *teach well one thing at a time.* The method of proof is quite different from that of the theorem. It is difficult for the average student

to grasp the order of proof of the theorem at the beginning, and it takes time to fix firmly the order and course of reasoning. To take up at the beginning the construction of figures would confuse the student and tend to discourage him. Yet it seems to me that if the student learns at the very start to bisect the angle, to construct the angle equal to a given angle, to erect the perpendicular, these operations give him a degree of conciseness that he cannot attain by performing these operations free-hand. Then, too, he has obtained a knowledge of the theorems that involve these problems that he otherwise would not attain.

Another problem is, how much numerical work shall be undertaken? Shall we teach all the "numericals" that apply to these theorems that are capable of solution? Yes, but not until the student has learned that his geometry can be developed independently of his numerical measures. When the proposition has been fully developed then get the numerical application of it. The one tends to supplement the other, but let the proof of the theorem precede.

Another problem that demands serious consideration is, how shall the recitation be conducted? Shall we employ the German method or the American? i. e., the method of class recitation, or the individual method. In our country, I believe, the plan is quite general to let the student work at the proposition for himself in preparing the lesson, and the following day to place it upon the board and have it explained to the class by one of the students, the rest listening and following the demonstration. In Germany quite the reverse practice is followed. New theorems are taken up by the class as a whole, the teacher guiding the work by questions. Much use is made of the notebook, and the work for the following day consists in reviewing the notes taken in the class. I believe I am correct when I say students do very little if any work when alone, in preparing the lesson for the following day, unless they have first studied the theorem with the class under the guidance of an instructor. But little work is done at home at any rate.

Neither method carried to excess is advisable, but the two may be combined with good results. A good solution of the problem is to ask various members of the class to supply reasons for statements made by the student who is giving a demonstration. Let the student himself first tackle the proposition before any help is

offered, unless it is on a topic that is being taken up for the first time, as with the locus of a point. Then it is advisable to guide the student, helping him to prepare his lesson. I have found it good practice to place upon the board figures which illustrate the review and to ask students to quote the theorems of these figures, hastily, a few of them each day, asking first one, then another for the various steps, one giving the part of the proof, another the reason. Ten to fifteen minutes spent thus before taking up the propositions of the day are well spent. I have learned that the Germans accomplish as much in mathematics as we in the United States, yet we devote seven-fourths as much time to it as they do. Why is this? Russell says in his "Higher Schools of Germany," geometry is introduced very early in most non-Prussian schools one period a week. The object is to familiarize the pupils with the essentials of geometrical form, to get them to look at things from a geometrical point of view. Solids are put in the hands of pupils first, and are discussed and measured to give correct ideas of surfaces, lines and points with their relations. The next step is to teach them to draw figures, and this forms a basis for the systematic study of plane geometry. The four years in plane geometry is ample time, not only to master the theory, but also for a variety of practical applications, impossible in a shorter course, or under a plan which does not provide for simultaneous exercise in arithmetic, algebra and elementary trigonometry.

Our students have algebra for one year, then geometry for one year, then, in many schools, no mathematics for a year; then trigonometry and solid geometry in the fourth year. The methematics comes in layers, and I am not certain but that it is better so. I would like to try a class in elementary algebra and plane geometry over a two-year course; algebra three periods a week for the first year and geometry two periods; the second year geometry three periods and algebra two. I would like to see our students in the grammar schools doing some simple work in geometry, not demonstrative. The German student is under the guidance of a trained specialist. He knows his subject and has had his pedagogical training. To sum up, we find the German student has his mathematical training over an extended period, under the direct guidance of a trained specialist, the student doing but little individual work.

The student of the United States devotes to the mathematics

seven-fourths as much time as the German student; he has his high school mathematics, one branch at a time, and, in the end covers no more ground. But I was interested to find that this question, "Does the German student become an independent thinker?" was answered as follows: No, for the poorest, very doubtful for the average, and yes, for the best in the class. How is it with us? I trust we secure independent thinking, but it is hard work to think, and so many students prefer to jump at conclusions. I believe if it were not for the originals we would get but little independent thinking.

Finally, no subject in the high school curriculum equals geometry in educational merit. To get the most out of it, students must love it, and in a majority of cases the degree of their love depends upon the enthusiasm of the teacher. He must be alert, active and the most interested one in the room. He must lead his students through the dark days of illogical reasoning into the light of logical reasoning, and to do this demands both time and patience.

AN INDEPENDENT CRITICISM OF CURRENT TEXTS.*

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Students of elementary geometry usually receive the impression that the subject begins with statements, called axioms, of utmost simplicity, and then proceeds with rigorous logic throughout the subject. A little attention will show that this is not true. Proofs adopted by one generation are often regarded as fallacious by succeeding generations, and what passes for proof at one time is not always accepted later by the same person.

Axioms.—Every science should rest upon precise ideas; but it will be found upon examination that elementary geometry as usually presented is based upon statements of which the student has no clear notion, initially, nor do the statements become intelligible upon the development of the subject.

"Things equal to the same thing are equal to each other."

This is usually the first axiom given, and it will be seen to consist of the following statements:

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* Address given before the Mathematics Section, C. A. S. and M. T., November 25, 1904.

$$\begin{array}{llcl} \text{If} & a & = & m, \\ \text{and} & b & = & m, \\ \text{then} & a & = & b, \end{array}$$

where *a, b, m* are not numbers, but geometric magnitudes of which the student has as yet no conception, and the statement involves a relation between parts of such magnitudes which is expressed by the words "equal to." Under what circumstances are two geometric magnitudes to be called equal? To the student it implies no more than the notion used in algebra, where the letters denote numbers only; and even in this connection it is never made clear. In algebra, the statement

$$a = b$$

means simply that these letters denote the same number, and that one may be replaced by the other in any expression without altering its value. If geometric magnitudes were denoted by symbols not previously associated with abstract numbers, the indefinite character of many statements would be at once apparent. Suppose we draw two rectangles and place a sign of equality between them; what relation would it express? Students often mistake familiarity with a notation for a comprehension of the ideas they are meant to express.

"The whole is greater than its part."

This is merely the definition of a *part* of a finite magnitude and is no more axiomatic than the statement that "a body which can be seen through is transparent."

Other axioms are equaly vulnerable.

Limits.—The treatment of limits is consistently fallacious. After defining a limit, it is customary to illustrate it by a series of operations having a *rational limit,* and then it is tacitly assumed that all operations which do not lead to an infinite number nor yet to a finite rational number nevertheless have a limit; and in this surreptitious manner irrational numbers are introduced into geometry. We can easily see that the limits of

$$1 + \tfrac{1}{2} + \tfrac{1}{4} + ----$$

is 2. But consider the perimeter of a polygon of 2^{n+2} sides inclosed in a unit circle; i. e.

$$2^{n+2}\sqrt{2 - E^n(o)}$$

where E is an operator such that

$$E(x) = \sqrt{2 + x}.$$

In some definitions of the length of a circle it is assumed that as n is indefinitely increased this expression has a definite limit though it is not at all obvious, and is at best only a visually verified assumption.

"If two variables are constantly equal, and each approaches a limit, their limits are equal."

This statement is known by heart to every student, and when he comes to it the end of the demonstration is in sight. In the so-called proofs of this theorem the variables are dealt with as though they were algebraic expressions; but in this case the equality becomes an identity and any statement involving the value of one is true concerning the other. I believe the commonly received proofs of this theorem, even in algebra, are fallacious. But when the variables are geometric magnitudes we are again confronted with the idea of equality. Some texts present the theorem graphically by means of line segments, thus restricting their proofs to *congruent* magnitudes.

We would fare better by dispensing with this theorem entirely, as its use will be found merely to conceal the introduction of undefined terms. For example, consider a regular polygon circumscribed about a circle, and suppose we have defined the area of a circle as the limits of the area of the regular circum-polygon when the number of sides is indefinitely increased, and the length of the circle as the limits of the perimeter. We first prove that

$$A' = \tfrac{1}{2} r p$$

where the members of this equation are but different expressions for the same number. Then

$$\begin{aligned} A &= \text{Lt } A' \\ &= \text{Lt } \tfrac{1}{2} r p \\ &= \tfrac{1}{2} r \ \text{Lt}\, p. \\ &= \tfrac{1}{2} r \ \text{Lt}\, p \\ &= \tfrac{1}{2} r c \end{aligned}$$

In this connection we might observe that the definition of the length of a circle unconsciously assumes that the original number of sides of the inscribed or circumscribed polygon, and the manner in which they are increased, is immaterial. For example,

taking the case of an inscribed square and then doubling the number of sides we get as the length

$$\operatorname*{Lt}_{n=\infty} 2^{n+2}\sqrt{2+E^n(o)}$$

and beginning with a regular hexagon we get

$$\operatorname*{Lt}_{m=\infty} 2^{m+1}3\sqrt{2-E^m(1)}$$

What justification have we for assuming that these expressions have the same limit? Yet these are but simple instances of the theorems involved in such a definition.

Ratio.—If *a* and *b* denote two line segments, $\frac{a}{b}$ denotes their ratio, which may, or may not, be a rational number; but is assumed to operate, and be operated upon, in the same manner as rational numbers. When we write

$$\frac{a}{b}+\frac{c}{d}=\frac{ac}{bd}$$

the statements have definite meanings when the letters denote numbers, as in algebra, but their interpretation requires serious consideration when the letters denote line segments.

Consider the usual proof that two rectangles have the same ratio as the products of their dimensions. Denote by M the *rectangle* whose dimensions are *a, b;* by N, the *rectangle* whose dimensions are a^1, b^1. We are to prove that

$$\frac{M}{N}=\frac{ab}{a'b'}$$

Consider a restangle R whose dimensions are a^1, b. Having shown that

$$\frac{M}{R}=\frac{a}{a'}\,,\quad \frac{R}{N}=\frac{b}{b'}$$

it is customary to proceed thus:

By *multiplying* the corresponding members of these *equations* we get

$$\frac{M}{N}=\frac{ab}{a'b'}$$

Now how do we perform multiplications and divisions, including the process called cancellation, but is seldom clearly comprehended at best, when our multipliers and divisors are rectangles instead of numbers? On the other hand, if M, N, R denote numbers, then they must be the numerical measures of their rectangles; yet this proposition occurs before we find the measure of a rectangle.

Definitions.—In mathematics, a definition should be merely the assignment of a name to a figure which has been shown, or is assumed, to exist. Yet this is violated in most current texts; sometimes the name is given and used in the proposition which establishes the existence of the figure defined, and at other times the existence is neither proved nor explicitly assumed. For example, parallel lines are defined and then follows the proposition that two perpendiculars to the same line in the same plane are *parallel.* We should first prove that the perpendiculars *do not meet,* and then define parallel lines. Again, having defined a perpendicular to a plane, it is proved that a perpendicular to each of two intersecting lines is perpendicular to the plane of the lines. In some statements of the proposition we are told that the perpendicular is at the intersection of the lines; but in any event it unconsciously involves the interesting little proposition that two intersecting lines have *at least* one perpendicular in common. The proposition, however, should precede the definition of a perpendicular to a plane.

The length of curves, the areas of curved surfaces and of plane surfaces bounded by curves, the volumes of solids bounded by curved surfaces, are generally defined unconsciously and then not always consistently. For example, the surface of a sphere is usually found by taking the limit of the surface generated by an inscribed regular polygon having an even number of sides, rotating about a diameter through a vertex. Then if we find the volume by cutting off corners from a circumscribed polyhedron by planes tangent to the sphere, either we give another definition of the surface of a sphere without any attempt to show its equivalence to the one already surreptitiously adopted, or we assume if the number of faces of a polyhedron circumscribed about a sphere be indefinitely increased in any manner so that each face becomes indefinitely small, the surface approaches $4\pi r^2$ as a

limit, r being the radius of the sphere. I believe such a proposition would transcend elementary geometry.

A prism is frequently defined as a polyhedron, two of whose faces are congruent, parallel polygons, and whose other faces are parallelograms. There are many classes of solids satisfying this definition which have none of the properties of prisms and which bear no resemblance to them. Any reasoning by which properties of prisms are deduced from this definition is wholly fallacious.

Picture Proofs.—A demonstration can make little claim to being a logical deduction from the hypothesis when it is not merely unintelligible without an accompanying figure, but also will not hold if another, though satisfying the conditions of the hypothesis, is substituted. I would suggest that one have read to him a so-called demonstration from any current text and see if he can follow the steps or construct and letter the figure.

In the statement of the data, a common error is to include unconsciously relations which are not given, and to express the data in terms of lines and points whose connection is to be established in the construction later on.

It is supposed that geometry should be of great use to lawyers; yet it would be unfortunate if laws and agreements were as loosely drawn and as ambiguous as propositions in geometry.

Paradoxes.—Instead of being mere puzzles, paradoxes serve useful purposes in mathematics, and the finding of fallacies is a fruitful exercise. It will generally be found that the assumption made is the same as we are accustomed to make in proofs considered sound; for example, in proving that every triangle is isosceles as in Ball's Mathematical Recreations and Problems, we fall into error in assuming that points occur in a certain order simply because they appear so in the figure. Yet we make the same assumption in nearly every demonstration, and on no better grounds. The fallacious proof just cited is just as rigorous as the majority which occur in texts in common use.

Proofs.—To prove a proposition consists in showing, to our own present satisfaction that the conclusion is a logical consequence of the statements contained in the hypothesis. It is not certain that it will stand in our maturer judgment or be accepted universally. The hypothesis, however, may be the result of a previous demonstration, or it may be a brand-new assumption.

Assumptions.—An assumption contained in the hypothesis or

the proof may be an independent postulate, or may be dependent upon previous assumptions when a proof of it is either too difficult to be comprehended by the student at the time, or when it is omitted through lack of time to devote to the subject. It is doubtful if anything is gained by taking a class through a demonstration they do not comprehend, since though theoretically there may then be no break in the logical continunity of the subject, there is actually a break in the student's knowledge of it anyway; and a real recognized break is better than a real unrecognized one.

I believe we may logically adopt the following principle:

Make any assumption, at any time, that may seem justifiable, and retain it until results based upon it are found to be contradictory to results previously accepted.

The number and character of those assumptions will depend on the circumstances, and in going over the subject a second time they may be reduced.

Doubtless many will disapprove of the use of assumptions which may introduce redundancies; but if so, to be consistent they should show that their original assumptions are themselves independent. This would, in general, be found beyond the power of both students and teachers. Moreover, the original axioms usually given are not independent; so in any case assumptions cannot be objected to on the grounds of redundancy. It is only lately that any attempt has been made to establish an independent set of postulates, and the work is not yet final. For centuries the parallel axiom was believed to be a redundancy, so that we cannot object on historical grounds.

Again, if this subject, or *any subject,* be based on "self-evident truths," then like all statements in whose acceptance reason has played no part, they are believed to be beyond the domain of rational criticism.

The liberty of making assumption is tacitly allowed in every indirect demonstration when we make an assumption and show that conclusions based upon it are not in harmony with those already held, and hence abandon the assumption.

PROGRESS IN THE CORRELATION OF PHYSICS AND MATHEMATICS.*

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Bradley Institute.

The progress that is being made in the correlation of physics and mathematics is so extensive as regards amount of territory covered, and the methods employed differ so greatly that it is almost impossible to rightly estimate its absolute value.

Prof. E. H. Moore of the University of Chicago writes "that distinct advances in this direction are being made in England, Germany and France, at least to the extent that first, the work in mathematics is treated as a single whole; second, it is done simultaneously with physics; third, it is done as far as possible by the same instructors. This facilitates actual and continuous correlation."

At a meeting of the Mathematical Club of the University of Chicago held during the last summer quarter reports were made showing progress on the Pacific coast, in the South and in the Middle West. A factor in this country tending toward correlation is the organization of such clubs as the Association of Teachers of Mathematics in the Middle States and Maryland. Its first meeting was held at Teachers College, New York City, on Nov. 28, 1903. Among the papers read were "The Laboratory Method of Teaching Mathematics," "Geometry in the Grammar School," and "Has Algebra Any Genuine Application?"

By such organizations as the Eastern Association of Physics Teachers this subject has received more or less consideration, the following quotation being taken from an address by Vice-President George A. Cowen, of Simmons College: "Fifteen years ago at Phillips Academy, Andover, Professor Graves performed the experiments while the boys looked and wondered. Now they do and know. With the change came the necessary demand for accurate measurement, but measurements of length and weight and force are of no use unless properly correlated. This is mathematics. Mathematics, it is affirmed, has made physics unpopular. Language without words would be about as sensible as physics without mathematics."

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* Address given before the Mathematics and Physics Sections, C. A. S. and M. T., November 26, 1904.

The methods that are being employed are illustrated by the following: Professor G. W. Greenwood, of McKendree College, writes: "We are trying here to bring mathematics and physics into closer relationship by showing that algebra is a means of expressing precise relations among magnitudes which may be measured and of expressing relations deduced from given relations. I am using entirely new definitions with these ends in view, and so far as I know they differ widely from the text books We take any verbal statement from physics or arithmetic and then state it in the form of an equation. From equations we state verbal equivalents or rules. We leave entirely in the physics department the experiments from which the laws are deduced, and so far we are making good progress."

From Professor Newhall of the Shattuck School we have the following: "The courses are conducted entirely separate, but the department of mathematics aims to teach such subjects as the metric system, ratio and proportion, variation, graph, a knowledge of the trigonometric functions, etc., before they shall be needed in the study of the sciences. The instructor in physics has written out for me a full list of the formulas, equations and geometrical proofs which occur in a year's work in physics, and I see that these identical equations and proofs are studied in the algebra and geometry. In return he emphasizes such subjects as the parallelogram of forces, direct and inverse variation, etc." Mr. Newhall also writes that they have a close correlation between the mechanical drawing and mathematics. Further he states: "I do not think I like the idea of correlating the two subjects to such an extent that either loses its identity."

Professor H. E. Cobb of Lewis Institute in outlining the interesting work he is doing says: "My experience is no doubt of value in this, that I am laboring under the difficulties that most teachers encounter when they try to get out of the beaten path. While I am free to use any method I choose in my classroom, at the close of each quarter and often during the quarter, students are transferred to or from my section. Hence I must go over the ground with the new ones, and always have my students in such shape that they can do work with other sections. In the first year algebra I use the balances and levers to illustrate the equation and the operations with positive and negative numbers. Squared paper is used in the solution of problems and graphical

work. During the last two quarters one day a week is given to concrete geometry, measurements being made in the metric and English systems, and constructions with compasses and ruler. In first year geometry great emphasis is laid on doing and on numerical computation. During the last quarter elements of trigonometry are introduced and triangles are solved, and computations of heights and distances made with the squared paper instead of tables of natural functions. In geometry various blocks are measured with both ruler and calipers, which are weighed and the volume and specific gravity computed."

Professor Donecker of the Richard T. Crane Manual Training High School of Chicago has devised a balance which he calls the "Algebraic Equation Balance," which serves the purpose of making it possible to present equations in concrete form. The primary purpose is to give a concrete idea of negative numbers. It can also be used as a basis for problems on levers. I suggest that every mathematical teacher investigate this apparatus.

Professor Risley of the Mathematical Department of Armour Institute of Technology outlines their work as follows: "We have gotten outside problems from the work in Physics and used them in our class work. We have not discarded a text, as some have advocated. In those subjects requiring mathematical statements and calculations our instructors agree that the difficulty is fundamentally one of arithmetic. The mistakes are made in adding, etc., and in getting the decimal point in the right place. Handling ordinary common fractions and in placing the work in a clear logical order. In our plane geometry practicaly all the work is original. This is somewhat slow at first and usually a little discouraging to the student for about six weeks. After that if the instructor has been sufficiently strenuous in exacting the niceties of geometrical logic, and clearness, there is a most pleasant outlook ahead. In our geometrical notebook we have a great deal of construction work illustrated by the following problems: Draw 5 lines of different lengths, measure them in centimetres and inches, find the ratio of the length of an inch to that of a centimeter in each case; also the ratio of the length of a centimeter to that of an inch in each case. Obtain the mean ratios. Why do your values differ from the true ratios. As another example: Draw 5 different angles, acute, obtuse and reflex. Measure each three times and obtain the mean. Describe the

process of measurement carefully. The student will not study construction as such from his text this term. The idea being to have him become thoroughly familiar with his inch and centimeter rules, his compasses and dividers, protractor, etc. Later he will consider the parallelogram of forces from data obtained in actual experiments. One primary object in our work is the development of the initiative, and we hold that analysis bears an important place in this development.

Dean Raymond of the department of Physics writes as follows: "We have found at Armour Institute of Technology that in attempting to do specified physics experiments with our mathematics classes, we sacrificed the formal drill in the manipulation of algebra expressions. This is too important a part of the training of an engineer to be studied in any but a rigid manner. In place of the "booky" problems that are found in almost every text, we have supplied a long list of problems from physics, especialy mechanics, etc. The law is stated and the student has problems to solve that arise from this law. The interest of the student is assured at the outset, knowing that he will later meet with the principle in his engineering work. Besides the interest of the student, he is being drilled to manipulate those forms which will make the study of the subject of mechanics or physics very much easier when taken up. Complaints were frequent from those teaching the applied mathematics that the men could not handle the mathematics of the subject after having made the application. The list of problems were written after scanning the books used in the engineering classes, in hopes that the mèn might be better trained to handle the work. From results attained thus far, we feel that the work is proving very beneficial."

It would be much easier for Prof. Comstock or Prof. Plant, who have so successfully and untiringly pushed the work of correlation at Bradley Institute, to outline their work for you and explain exactly how and why it was begun. From the point of view of the physicist it commenced some six years ago when the mathematics department discarded the algebras then in use and made out in outline one which used extensively the graph and introduced a large number of physical problems. These problems were selected in what appears to me now an almost ideal manner. The physics department furnished a list of all the typical equations used in elementary physics and later a series of problems

which covered every type of equation. The mathematical department then selected from these and added many others which appeared especially well adapted to students in elementary algebra. From physical problems to simple apparatus, such as balance, lever, thermometer, etc., was only a step, and the logical outcome of the introduction of such work. This work has been developed along this line until it seems to me as I come in contact with the students taking the course, to be very successful.

In geometry the students were first given a few plane figures to find their dimensions in both the English and metric systems. Various geometric problems that had a more or less direct bearing on the physics were introduced.

Two years ago the mathematical laboratory for work in concrete geometry was established. This simply meant the better systematizing of the experiments already given and the addition of many more. Some of these experiments were taken directly from the physics, while others were original and not ordinarily given at the present time in the elementary physics. Great care was taken in the selection of these experiments to include only in general those that have a geometrical proof, thus enabling the student to obtain a very clear comprehension of the practical applications of his geometry. The second object that was aimed at was the selection of experiments which required only the simplest form of apparatus. Those which do not fulfill this latter condition are, in my opinion, absolutely worthless for elementary mathematics. As soon as the apparatus becomes sufficiently complicated to need explanation by the instructor, the student has his mind turned from the essentials of the experiment to the apparatus. It is not the aim of this laboratory course to teach the student manipulation of complicated apparatus.

It was early recognized that it would be impossible to have a close correlation between the physics and mathematics unless the instructors were familiar with the work of both departments. For this reason one mathematical instructor taught three-fourths of his time in mathematics and one-fourth in physics, while one of the physics instructors gave three-fourths of his time to physics and one-fourth to mathematics, i. e., the physics instructor had one class in geometry or algebra and the rest of his time in physics. This also furnished a bond of interest between the two departments, in that each knew the aims and objects of the other.

The results obtained from this arrangement cannot be overestimated. It seems to me doubtful if as much could have been accomplished in any other way, at least it would have required a much longer time. Another feature which contributed materially to the success of this correlation was the introduction three years ago of a course in physiography, which is taken by all students during the first quarter of the first year. This course given under the direction of the physics department is made an introductory course in science, so that the student is more or less familiar with the words and phrases that he will be required to use in his problems in algebra and geometry.*

Thus we have outlined briefly the work of correlation as it is being carried on in some schools. There are many others where the work is probably as far advanced as in the cases noted, but I was unable to obtain accurate and specific information concerning them. A pertinent question would be: What assistance has this been to physics? The student is familiar with many of the words like velocity, acceleration, force, centigrade, etc., the metric system in detail, and the graph. He can solve all algebraic equations occurring in physics with numerical problems under each. The working of examples in the composition and resolution of forces with the trigonometric functions—sine, cosine and tangent, is but a continuation of his work in geometry. The laws of the lever, reflection and refraction of light, of the inclined plane, and the relation between the Centigrade and Fahrenheit thermometers come as easy as the simplest equation in algebra. From his laboratory work he is familiar with the method of doing accurate laboratory work. He knows the *degree* of *accuracy* which he may expect to obtain, i. e., a clear relation between the theory and practice. He is also familiar with the sources of error, form of laboratory report and he knows the best methods of computation.

There are of course many others, but beside all these which we can state more or less definitely he possesses the power to use his mathematics to a degree that is almost unknown to students who have not had this work.

Another question which is often asked and which is certainly much to the point is: Do these students know their pure mathe-

*Note.—These experiments were published in full in a report of the committee on the correlation of mathematics and physics in secondary schools made to this association in 1903.

matics as well as students who have had only the abstract mathematics? This is, of course, a very difficult question to answer. I have made an attempt to find an answer in this way. I have in my classes not only students who have taken this work, but also students who have come to us from first-class high schools where I know that the preparation in pure mathematics is very good. I have sometimes asked for the proof of some geometrical theorem that we have been using, as for instance the Pythagorean theorem. I have never yet found a student with only the abstract preparation who would attempt to demonstrate one of these off hand. While I have found that a large number of the students who have had the concrete geometry were able to give the demonstration.

While this cannot be considered in any sense a proof it certainly indicates to me that the student has lost none of his reasoning powers by taking up this applied work. That I am not the only teacher who believes that the concrete work has added materially to the student's power to deal with mathematics is easily seen from the following: Professor Cobb of the mathematics department of Lewis Institute, who has made decided progress in the correlation of physics and mathematics, says: "I am thoroughly convinced that my students are getting hold of mathematics in a way that is not possible under the old formal method of teaching." Again, to quote from Professor P. B. Woodworth: "I take great pleasure in reporting progress in the correlation work in mathematics and physics at Lewis Institute. I have been more than pleased with the results as they develop this year. The students who had the mathematical work based upon actual measurements are much better prepared than those who have had the same amount of abstract work in mathematics. The work seems in some way to have developed a thinking mathematical method which largely prevents those mathematical blunders which have been so exasperating to physics teachers. I also think the attempt at precision measurement has increased the students' reverence for mathematics. The only ill effect I have observed is that those who have not had the course given by Professor Cobb are havi .g a hard time to get in line." Professor R. A. Milliken of the University of Chicago quotes Mr. Lynde, instructor in physics at the School of Education, as saying that the students who took the concrete mathematics and have now

entered physics take to the graph like ducks to water; beyond this he is not prepared to make a report at present, as this is only the second year that the physics courses at the School of Education have been in operation.

From the statements of various persons quoted in this paper, and from many others which I have obtained, it seems that correlation does not mean that either physics or algebra or geometry is to be eliminated, but, as Dr. Milliken very aptly expresses it, "you can teach all the p'ysics you want in algebra and geometry and then there will be pienty left for us."

It appears that the correlation is an accomplished fact in so far that problems from physics are made the basis of the original work in algebra and that wherever this work is carried on we find both the mathematics and physics teachers enthusiastic concerning the progress of the student in his power not only to use his mathematics, but he seems to possess a clearer and a more logical and a more correct idea of the abstract mathematics. It would seem that to attain the highest degree of efficiency in this work, not only must the teacher of mathematics be a student of physics, but if possible he should teach physics for a time in order that he may better comprehend the needs of the physics teacher and at the same time study carefully in all ways the effect that the correlation is having on the student's work.

RECENT ADVANCES IN METEOROLOGY.*

BY HENRY J. COX, A. M.,

Professor of Meteorology, United States Weather Bureau, Chicago, Ill.

(Continued from the February number.)

GENERAL AND SECONDARY MOTIONS OF THE ATMOSPHERE.

The kite and balloon observations, and the international cloud observations which were carried on all over the world in 1896 and 1897, seem to throw new light upon the motions of the atmosphere, and have led meteorologists to give up Ferrel's canal theory and the German vortex theory, which was at first advanced by Overbeck. The motion of the air in a cyclone, coming more and

* An address delivered before the Earth Science Section of Central Association of Science and Mathematics Teachers, Nov. 26, 1904.

more from the right as we ascend, disappears aloft in the eastward drift, and the observed outflow in the upper air is merely the interchange of motion from the local to the general circulation, as the cyclone lifts its head into the prevailing westerly winds. Both Ferrel's and Overbeck's theories require a warm center for the central depression, but all our observations disprove it, not only in this country but also abroad. Professor Hann's investigations on Mt. Sonnblick, Austria, do not support the theory of a warm centered cyclone, and he contends that a storm is a large eddy in the circumpolar whirl, and that local thunderstorms and tornadoes are smaller eddies in the secondary whirls. This theory assumes a difference in velocity between adjacent portions of the eastward drift like whirls in a stream of water, and this explanation seems quite plausible.

Bigelow has advanced a theory that counter currents of different temperatures in the lower strata of the atmosphere cause storm development, but it seems to us that these currents are the effect of the cyclone and not the cause. He states that storm development in the United States most frequently occurs on the eastern slope of the Rocky Mountains, and is due to warm southerly winds from the Gulf of Mexico meeting cool northwest currents which flow over the mountains. Bigelow has drawn in his experimental work isobars for storms at altitudes of 3,500 to 10,000 feet, as well as at sea level. He finds that the number of closed isobars around a cyclone center decreases with the height above ground, until finally a point is reached where they disappear. In the winter the cyclone head is only two or three miles high, but in summer it reaches to greater elevations. The storm decreases in force with the altitude—that is, the isobars widen out

Professor Bigelow concludes that the West Indian hurricanes are formed by counter currents in the high levels, from the cumulus level to the cirrus level, four to six miles above the surface and the tornadoes by counter currents one to two miles above the ground, each overflowing a layer of stagnant air, wherein the vortex tube burrows down to the ground. Similarly the hurricane is an immense vortex tube formed several miles above the sea, which penetrates to the surface through the quiet lower air and is carried forward by being immersed in it. The gyration produces a low pressure at the center and a high pressure outside. Bigelow's investigations will be referred to later in connection with the Barometry.

REMARKS UPON BAROMETRY.

You are aware that the barometer readings as they appear upon our weather maps are reduced to sea level. The readings at all the stations must, of course, be reduced to a single plane to be comparable. Six different methods of reducing the actual pressures have been employed by the Weather Bureau for considerable periods as follows:

Guyot's Tables, 1870—1881.
Abbe & Upton Tables, 1881—1886.
Ferrel's Tables, 1886—1887.
Ferrel & Hazen Tables, 1887—1891.
Hazen's Tables, 1891—1901.
Bigelow's Tables, Jan., 1902, to date.

Time will permit me to touch only briefly npon the tables that have recently been in use. It should be understood that the reduction consists in adding to the observed reading an amount varying with the elevation above sea level and the temperature of the air and the correction expressed in tenths of inches of mercury should represent the weight of the air column between the level of the station and that of the sea.

Hazen's tables were the result of a series of experiments carried out with the aim apparently of making the isobars of the Rocky Mountain Plateau region smooth out. Their chief claim to merit seems to be the ease by which the actual work of reduction can be done. These tables were constructed prior to those of Ferrel, and the thermal effect of the Plateau, as well as the variation of correction due to changes in pressure was not a factor. As a consequence, pressures in areas of very low surface temperature were undoubtedly exaggerated. Exceedingly high barometric pressures were charted on the weather maps, especially over the northern part of the Plateau region, which the direction and velocity of the wind did not substantiate. These tables were a partial return to the ideas of constants, for, although they made allowance for variation of temperature by using diurnal means, a constant correction was employed for all pressures. The adoption of Bigelow's tables, which superseded Hazen's, January 1, 1902, brought a return to the ideas and arguments of Ferrel, but with the view of determining the solution of the different factors more perfectly. Other than the factor for vapor tension, the most important part of this work is the attempted elimination of error

due to an incorrect value of the mean temperature of the air column. The Hazen tables used for this value the mean of the current and the preceding observation temperatures. The Ferrel tables used the same value plus a correction depending upon the upward vertical temperature gradient. In the Plateau region, however, the vertical temperature gradient does not possess the same values below the level of the station as it does above, and consequently his argument was often open to improvement. In winter anti-cyclonic areas, especially, when the surface is enveloped by a comparatively thin layer of very cold air, the pressures are exaggerated by the Ferrel tables and much more so by the Hazen tables, which made no correction for the mean temperature of the air column. Professor Bigelow arrived at his values for this mean temperature at the periods of very cold surface air in rather a unique manner. Reasoning that a reduction of pressures for Plateau stations to a plane of 3,500 feet above sea level would give rise to only inappreciable errors, owing to the small vertical distances through which the reductions would be made, and that the isobars drawn from them would therefore present the same general shape as those of the underlying sea-level plane, he made such reductions for the plateau stations and reduced the adjoining lower level stations to sea level, for a series of cold weather observations, synchronously made. Then isobars were drawn for each system separately and the ends of the lines of the one joined to those of the other. Next, the values of the 3,500 foot reductions were abandoned, and each line was given the value of the sea-level isobar to which it was joined. Finally the sea-level pressures were interpolated from these maps, and by reducing backward, the temperature of the air column necessary to produce that pressure was found. The values for periods of higher temperature were worked out by a series of approximations, as data for such times were more numerous and available.

The Bigelow method is an improvement, although it cannot be considered perfect. Moreover, any change in the mode of reduction works, temporarily at least, a hardship upon the forecaster, as the previous charts with pressures reduced by other methods are not fairly comparable with those reduced by the Bigelow system. It is the practice of our best officials to make a close study of old weather maps, investigating the various types of storms, cold waves and other phenomena as they have been

chartered, and some forecasters, especially those located in the Plateau region, have been obliged to abandon the use of the study charts employed previous to 1902.

Bigelow's work upon Barometry is, in my opinion, deserving of great commendation. He has gone into the subject very carefully, and in addition to preparing new tables for reduction to sea level, he has made up tables for reducing all barometer readings to planes of 3,500 and 10,000 feet. The Weather Bureau will make practical use of these high level reductions beginning December 1st, next, by entering them upon supplementary charts for use in forecasting. The 3,500 foot plane affords an easy reduction for all stations, those near sea level and those at higher elevations, while the 10,000 foot plane marks the level of the strato-cumulus clouds, the location often of maximum cyclonic circulation, in winter it being lower, and in summer higher. We must admit that the reduction of barometric readings to any plane is imperfect, unless we know the temperature of the air column. The weak point in the system is, of course, the temperature gradients, and only a more complete survey of the upper air over the United States by means of balloons and kites will permit a more satisfactory solution. Bigelow has to assume normal temperature gradients in his reductions, the normal gradients in highs being less than in lows. By his method the highs disappear at about the 10,000 foot level.

With reference to use of these high level charts in forecasting, he writes as follows in the Monthly Weather Review of February, 1903:

"1. The advance of the center of the low pressure is controlled by the upper strata, and its track for the following 24 hours is usually indicated by the 10,000 foot isobars.

2. The velocity of daily motion is also dependent upon and is shown by the density of the high level isobars.

3. The penetrating power of the cyclone is safely inferred from an inspection of the three maps of the same date.

4. There is a decided evidence that areas of precipitation occur where the 3,500 foot isobars and the 10,000 foot isobars cross each other at an angle in the neighborhood of 90 degrees.

5. There have been several cases in which the formation of a new cyclone has been first distinctly shown on the upper system of isobars before penetrating to the surface or making itself felt at sea level."

BOWIE'S THEORY OF STORM MOVEMENT.

Mr. E. H. Bowie of our St. Louis office recently read a paper before the Convention of Weather Bureau officials held at Peoria, Ill., in which he discussed "A Possible Method of Determining the Direction and Velocity of Storm Movement." Bowie reasons that storms in the United States would move directly with the eastward drift, were it not for the irregular variations in pressure surrounding them. He endeavors to obtain a resultant of the various pressures acting from all directions towards the storm center, and he uses this as one of the components that determine the storm's path. The other component is the eastward drift, the exact direction of which he has calculated for the various months in different sections of the country. Allowing these components equal values, the resultant is the direction and movement of a given storm. The values determined by Bowie's method are necessarily approximations only; yet his conclusions are reasonable, as can be seen by a study of the maps. However, the pressure component cannot be calculated unless the storm is well within the confines of the United States, and it is therefore impracticable to employ the scheme, when a disturbance is in either the extreme north or extreme south. Bowie has used his method to advantage in forecast work during the last three years; in fact, he is one of our most successful local forecasters.

MOUNT WEATHER RESEARCH OBSERVATORY.

Research work in higher Meteorology has now become very active, and countries abroad have in many cases provided special observatories for the study of the dynamics of the terrestrial atmosphere and for work in solar physics. Progress cannot well be rapid, as the meteorologist can only after years of preparation begin work of this character. In fact, in order to accomplish much in the field of solar physics, he must be a mathematician, an astronomer and a physicist, as well as a meteorologist. In order to gain any appreciable results, an enormous amount of work must be done. This may be true also in other sciences, but in none more so than in Meteorology. The task is also great, because investigations of many subjects have to be made. It seems that enough has been learned about the activities of the sun to justify us in endeavoring to establish relations between them and certain changes in the earth's atmosphere. If even only a little is gained

in the improvement of our forecasts, the work will be well worth the doing. It is yet our hope that the goal may be reached, that meteorology may become an exact science, and that seasonal forecasts may be possible.

Our own government gives promise of now attacking the various problems in an energetic manner, and with this end in view the Mount Weather Research Observatory has been established under the direction of Professor Moore, Chief of the Weather Bureau. It is located on the Blue Ridge Mountains, overlooking the Shenandoah Valley, near Bluemont, Va., and it will be fully equipped for conducting researches in terrestrial magnetism, atmospheric electricity, solar physics, explorations of the upper atmosphere by balloon and kite ascensions, spectrum analysis of the aurora and lightning, the radioactivity of the atmosphere and of the ground and other allied problems. In fact, Professor Moore expects to have every subject investigated that may possibly have any bearing upon the science of meteorology. It has been said that the meteorologist has all-out-of-doors for a laboratory, but buildings are also necessary, and several have already been completed. The site of the observatory contains 89 acres, and it will afford ample room for field work. It is realized that many years will be required before any very definite results are secured, and as these become apparent it is probable that additional research observatories will be constructed in other sections of the country.

MISCELLANEOUS STUDIES OF INTEREST.

We forecasters have little opportunity for work of this character, but can at least keep in touch with current meteorological literature and work along the old lines of studying and correlating weather types as they appear upon the forecast charts. Moreover, the study of Climatology is always interesting, and even in that branch of the science the investigator may delve into the mysteries of either Medical or Agricultural Climatology.

The Chicago Weather Office has been engaged in various investigations, and the one now being pursued is the study of the occurrences of frost in the cranberry marshes of Wisconsin, as the growers depend upon our warnings for the protection of the berry. We have found that in the marshes the temperature is often 10 to 15 degrees lower than in the surrounding uplands, the cool air settling down into the valleys on clear nights. Furthermore, the

radiation of heat from the bushes is enormous. Radiation is much greater from soil covered with vegetation than from the bare ground, and it depends upon the specific heat of the soil. The specific heat of the black soil of the Wisconsin marshes is low compared with that of the sand found in the marshes of Cape Cod, and consequently frosts cause the Wisconsin grower greater injury. His motto now is: "Use sand and watch the weather forecasts."

The relation between weather and crime and the different effects of different kinds of weather upon the nervous system will always afford interesting studies, but before closing this paper I desire to add a word of caution to investigators. Do not proceed too rapidly, and at all events be sure of your ground. My attention was recently invited to a publication prepared by Professor Dexter of our State University discussing the effects of strong winds upon persons with suicidal tendencies. According to his calculations, the wind has much to do with the suicidal mania, and he concluded that the number of suicides was greater in Denver, Col., than in New York City for corresponding wind velocities. In other words, it required less wind in Denver to tempt a man to self destruction than in New York. Of course, the professor used the Weather Bureau records of the two cities, which apparently show that New York is more windy than Denver, but the velocity is higher in the former city simply because the anemometer there is exposed at a great elevation—in fact, at a height equal to that of the Auditorium Tower in Chicago. It consequently normally records about 25 percent more wind than the instrument in Denver. It has not been found practicable to apply corrections to these observations, as the exposures in the various cities are very unlike. It should be obvious that such records are not fairly comparable.

TOPIC OF INVESTIGATION SUGGESTED BY PROFESSOR ABBE.

Professor Abbe, who is here today addressing another section of this convention, once suggested an interesting topic for study. It was a few years ago at a convention in Omaha, Neb., that I heard him speak as follows:

"When you think this is a lovely day, make a note of it. It may exhilarate you, or it may quiet you, but anyhow make a note of the fact that with this wind, this temperature and with this

moisture, you feel first rate. Keep this little record for a year, and when you get through you will see what a great variety of atmospheric conditions you have experienced and yet felt magnificently every time. Do not let this seem like a *reductio ad absurdum,* but send these data to me and I will put them in a little chart that will illustrate the subject very instructively. The horizontal line will be for the relative humidity and the vertical line for temperature. The figures for wind velocity will be written at the proper point to indicate that one feels first rate at that temperature, humidity and wind. Eventually we will have a line of perfect comfort, and this line differs wonderfully through the year, as we adapt ourselves to the seasons."

INSTRUMENTS FOR TOPOGRAPHIC SURVEYING.

BY WILLARD S. BASS,
Francis Parker School, Chicago.

An excuse is needed for taking the time of this meeting to discuss apparatus which has already been described in print.* My excuse is that since writing the description of the apparatus I have used it with a class, and the experience has resulted in some modification of the apparatus and also in my opinion of its effectiveness and educational value. I will speak first and briefly of the value my experience has led me to put upon work with the apparatus and then of the apparatus itself.

I have, in the first place, found the apparatus practicable, both in construction and use. Most of it was made by a ninth grader in the manual training room, and no unusual difficulties were encountered. The making of the apparatus cannot be regarded as so educative as is its use, and we, therefore, had it made good enough to become permanent equipment of the school. The use of the apparatus gave results accurate enough to satisfy the pupils. Maps constructed by data obtained by its use did no violence to one's eyes. The errors of the best pupils were not over two per cent.

The time required to map a city-block was greater than expected; so great, in fact, that the work had to be left unfinished at the close of school last spring. All members of the class, how-

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* School Mathematics. Vol. I., No. 2, March, 1904, p. 207.

ever, finished maps representing the region as a plane, and had done some leveling; a few had determined contour points and were ready to begin to draw contour lines. Looking only at the maps, one might be inclined to say that they were not worth the time required to make them. But the maps were not the only result of the work. The pupils gained greatly in their accuracy of work, in their understanding of some geometrical truths, and still more in their power to apply these truths to concrete cases, and in the ingenuity in overcoming practical difficulties. Considering these results, I felt that the work had paid well.

I found also that small groups are most effective. In a group of two or three, each pupil gets a chance to do every kind of work the group is doing, and gets a comprehension and share in the solution of all the difficulties which are encountered. In larger groups this is seldom the case; instead, two or three of the brightest ones are apt to do all the thinking. The pupils also like better to work in small groups. I first planned to have my class work in groups of three, but they asked to have the groups changed to two and constructed the additional apparatus necessitated by this change.

I might also say, while speaking about my experience, that the pupils liked the work and kept at it enthusiastically to the very end.

While I became interested in this work originally on account of the openings which it gives for mathematics, yet it has two values which should be of especial interest to teachers of Physiography. In the first place, it necessitates the careful and detailed study of an area. The value of this naturally depends somewhat upon the character of the area chosen. But there is no region in which new facts of slope and drainage will not be discovered by a careful survey. In the second place, the pupils gain a better understanding of topographic maps and greater ability to read them.

Several methods of giving the pupils greater power to interpret topographic maps have already been discussed here this afternoon. They have been alike in seeking to make the contour map more vivid by reconstructing it in three dimensions, building up a more life-like and natural image of the region mapped. It is no disparagement of making models to say that the construction of a contour map from a survey possesses a kind of value which the

former does not. The latter necessitates the constant comparison of the contour lines with the actual slope which they represent, and thereby the pupil becomes able to translate his map back into the actual region. This to my mind is a greater achievement than to translate it into a three dimensional model. I do not mean that the construction of the map from the survey will do away with the necessity or desirability for making models, especially of inaccessible regions; but it will help the pupil to read into both and model the regions which they represent.

Apparatus good enough for this work and cheap enough to be purchased in sets by ordinary schools is not at present on the market. It is my chief object to show how such apparatus may be obtained without too great a cost in money or labor.

The apparatus needed for a group of three in topographic surveying consists of a tripod, plane table, alidade, two flag poles, a measuring tape, set of pins, level, leveling rod, and, if inaccessible distances are to be measured, a stadia and stadia rod.

Tripod.—A tripod sufficiently rigid to support the plane table without excessive vibration may be purchased for about $1.25. The sliding legs permit the ready leveling of the plane table and level.

Plane-Table.—The plane-table, 24"x20", was made by the pupils. The material used was ⅞" soft pine (⅝" would have been sufficiently heavy). The board was made 22"x20", of three pieces glued together. Strips 20"x1" were then nailed with long nails across the ends. There has been, up to date, no trouble from warping. The table is attached to the tripod by means of a brass camera plate permanently screwed into its under side, the surfaces of the two being flush. The camera plate is threaded to receive the screw of the tripod top.

Alidade.—The alidade was combined with the stadia. The combined instrument consists of a base 24"x2½", whose edges are carefully planed straight. At either end of this, base blocks 2½"x 1¾"x1¼" are screwed. The central portion of the lower side of each block is cut away so as to receive the end bearing of a Stanley level sight. These level sights are made to screw to the tops of wooden carpenters' levels. The rear sight has a round hole, and the fore sight a single straight horizontal wire. For use on the alidade they are fastened to the blocks so that the wire is vertical. The blocks are then screwed to the board so that both the

hole and the wire are over the left-hand edge of the board. Care should be taken to have the vertical wire perpendicular to the base. It is not essential that the line of the sights be exactly over, or even exactly parallel, to the edge of the alidade. The only effect of an error in this regard is to rotate the entire figure without changing its shape.

Flag-poles.—Material used was pine. Poles were 6′ long, 2″x 2″ at bottom and 1″x1″ at top. They were first planed square, then octagonal and were painted red and white in alternate bands one foot wide. To enable the poles to be stuck upright in the ground the lower end was rounded and a ferrule of 1½″ gas pipe driven over it; a hole was then bored into it and a ⅜″ iron rod one foot long was driven four or five inches into the hole, leaving seven or eight inches to be stuck into the ground.

Measuring-tape.—A 50-foot "treble" linen tape divided into tenths of feet was used and found satisfactory.

Measuring-pins.—Wooden stakes may be substituted for these. They will not be used much unless there are long distances to chain.

Leveling-rod.—Used an architect's rod (Keuffel & Esser, No. 6,281). It was not very satisfactory, as the disc is too small to be read with naked eye at any considerable distance.

The total cost of the apparatus is summarized below. Most of the articles are standard and can be purchased anywhere at about the given figures. In case anyone should have difficulty in finding satisfactory articles at these prices the writer will gladly furnish the names and addresses of the firms which have supplied him.

Tripod, $1.50; camera tripod sockets (two), 5 cents; level, 50 cents; level sights, 75 cents; measuring tape, 50 feet, $1.50; chaining pins, 85 cents; lumber, 35 cents; iron for flag pole, 5 cents; total, $5.55.

The most important modification of the apparatus from that previously described in the Journal of School Mathematics is the substitution of a water level for the carpenter's level and level sights used at first. The latter was sufficiently accurate, but proved too difficult of adjustment.

Water level.—The water level is constructed by turning up about ½ in. on each end of a glass tube 25 in. long and ¼ in. (or more) in diameter. (See Figure 1.) On each of these upward pointing ends a one-holed rubber stopper is placed of size suitable to fit the upright tubes described next. These upright

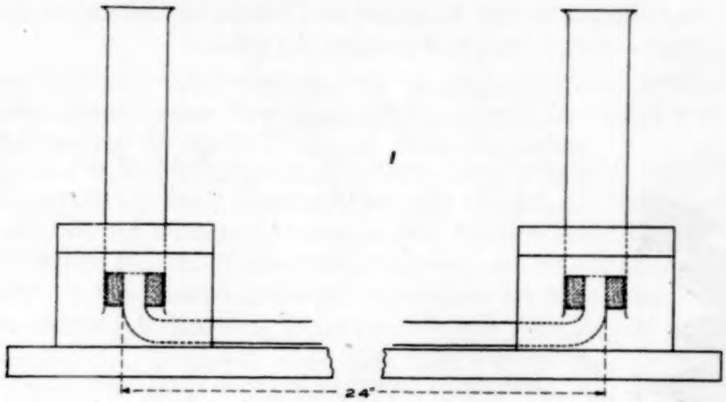


FIG. 1

tubes should be of clear glass, 3 or 4 inches high and three-quarters of an inch in diameter. (See Figure 2.) If the diameter is smaller, it will be difficult to see the water. Excellent tubes can be made by cutting off the bottoms of ¾-inch test tubes and rounding out the edges in the flame of a Bunsen burner. The tubes are pushed down over the rubber stoppers, and the whole is supported in a suitable wooden frame. It is convenient to have a camera plate screwed into the bottom of the frame so that it may be mounted upon a tripod. To use the level one has only to pour in water until it stands about half way up in each of the upright tubes, place the apparatus upon a tripod or other support level enough to keep the water from running over the top of the tubes. The observer holds his eye about 10 in. behind the nearer tube and on a level with the water, and looks along the sides of the tube—*not* through them—and uses the *bottom* of the meniscus in the tubes to determine the line of sight.

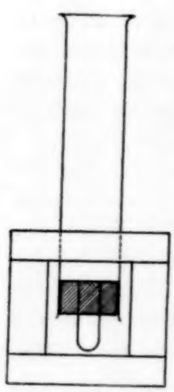


FIG. 2

Target.—It is necessary to have some kind of a leveling target to use with the water level. The purpose of the target is to determine how high the line of sight is above the ground, at the places whose difference in level is desired. The target described previously may be used, in which case the person at the target reads the distance from the ground. A more convenient form for distances under 200 feet is the stadia target described below. (Figure 3.) In using it the person at the level observes the place where

the line of sight strikes the target and counts the number of feet and tenths of feet from that point to the ground.

Stadia and Stadia Target.—Two pieces which I have not tried with a class, and therefore recommend with some reserve, are a stadia and stadia target. The use of the two will save a great deal of chaining of distances between 50 and 200 feet. Within these limits the instrument has worked with an error less than 2 percent. Beyond two hundred feet the difficulty of using the instrument increases rapidly and the accuracy diminishes. For distances under fifty feet there is no advantage in its use.*

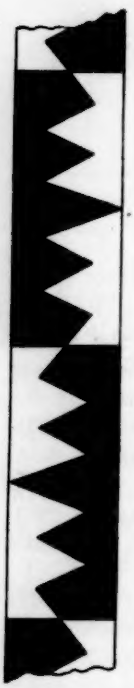


FIG. 3

The stadia found to be most effective had a constant of 25. It consisted of two fine black threads, stretched across an opening in a piece of cardboard and fastened there by glue. These threads constituted the fore sight. The hind sight consisted of a small circular hole countersunk in a piece of brass. (Cardboard would have answered.) The distance of the hind sight from the fore sight was made as nearly as possible 25 times the distance between the threads of the fore sight. When this is the case the distance to any object will be 25 times the vertical height which the threads intercept on the object.

The stadia target is designed to enable the observer at the stadia to read this vertical distance directly, and thus to be able to write down the horizontal distance between him and the target without anyone having to walk the distance. It consists of a conspicuously painted board 10 feet long and 5 inches wide, divided into feet and tenths of feet. The pattern shown in the accompanying sketch (Figure 3) was painted red and white and could be read with certainty to a tenth of a foot at a distance of 170 feet.

If the above form of stadia target, which is called self-reading, is used, a flag pole and leveling rod become unnecessary. An observation upon this one rod with the alidade will give its direction from the observer, with the stadia he can get its distance, and with the water level the height of his line of sight above the ground at that point. These three things are all that is needed for the construction of a contour map.

ECONOMIC AND INDUSTRIAL ASPECTS OF SECONDARY SCHOOL BIOLOGY.

PROFESSOR S. A. FORBES,
University of Illinois.

I am to speak on the "Economic and Industrial Aspects of Secondary School Biology," but the biology of the secondary school, as I have seen it, has no industrial or economic aspects, and with this statement and its demonstration I might plead that my duty to your program was technically fulfilled. There would be little value, however, in such a treatment of our topic, and little satisfaction in such a conclusion, and I must suppose that the question we have to discuss is virtually this: Do we wish to give an economic aspect and bearing to our secondary school biology; and if so, how may this be done?

I think it will help us to conclusions on this subject if we make some partial survey of the field of economic biology, in order to see what there is in it of value which is possibly available for the high school, and in order to distinguish the biological methods which a study and application of economic biology exercise and require. We must also distinguish the different views and plans of high school work in biology now current among us, and must try to ascertain with which of them economic and industrial biology will best affiliate; and we must come to conclusions as to any modification of plan and method in biological teaching which this affiliation would require. Finally, we should endeavor to estimate the gains and the losses, and the balance between them, which the introduction of the economics of plant and animal life would bring to the high school course.

It will be a great convenience to me, and will make, I think, no essential difference in the outcome, if I am permitted to confine myself to that part of biology with which I am most familiar, speaking of economic and industrial zoology only.

The first impression, I think, which one will receive who scans carefully the subject matter of economic zoology will be that of the bewildering amount, the variety, and the unexpected importance of its material; and the second impression will be that of the heterogeneous and disconnected character of this material, such as to defy organization on any lines of natural unity. It forms a huge pile of bricks, many of them broken; of gravel and plaster and cut stone; of boards and beams and pillars—the

plunder and wreckage of a great building, quite unfit to be built into anything complete in itself, and either to be taken as a mass of separate facts which can at best be assorted merely into more or less orderly series, or else to be supplemented by other building materials, not at all economic, if any self-consistent structure is to be put together.

Indeed, if we are to do anything with the economic feature in high school biology it must be limited, locally and practically, and made to include only those matters of fact and those modes of action which may be supposed immediately applicable to the economic and industrial welfare of the individual American citizen or of the American people at large.

Furthermore, if the subject is to be really economic, it must be so presented and so taught as to be economically and industrially useful to the very persons studying it. It must impart knowledge and it must give training which will enable the successful student of it to recognize and interpret the facts of his own experience, and it must end in effective economic action.

Let us work out our topic, then, on the idea that economic zoology for the American high school is that part of zoological knowledge and economic practice which shows the American citizen what he may do to avail himself and others of the benefits and to protect himself and others against the losses and injuries which American animals may bring to him or to other members of his social or political group. This not only greatly diminishes the number of the objects of our study, but it cuts out at a stroke all those parts of the zoology of the economic animals themselves which have no bearing on effective action directed to the economic end. On the other hand, it emphasizes the importance of the fullest knowledge of those parts which *are* so helpful, however insignificant they may be in the scientific sense; and it gives an indispensable value to that kind of personal training of eye and hand and mind which is necessary to an intelligent acquaintance with the features of one's own environment and to a rational program of procedure which may be adapted to any emergency. Furthermore, many of the facts of economic zoology are of national importance, and call for state and national action in the common interest, and this common interest is often antagonized by certain private interests which will fight persistently for their own and against the public welfare. The protection of the fur-

seal, the preservation of game, the renewal and multiplication of food fishes, and the protection of useful birds, are examples of these interests. We must appeal, consequently, to the public spirit of our high-school boy, must define for him the public interest in this subject, and must prepare him to discharge his duties as a citizen in this regard; and this is economic zoology of the best and most useful kind.

Chosen with these ideas in view, the body of available zoological matter will be limited to a relatively small list of injurious and beneficial animals selected mainly from insects, fishes, mammals and birds, including, of course, the domesticated animals, and to this we must add such general biological and economic topics as are of real value for our purposes. I think we may say that the ground will be fairly well covered if the high-school graduate has a familiar acquaintance with certain applicable facts about, say, a hundred species of insects, twenty kinds of birds, a dozen mammals, a score or so of fishes, and a brief but carefully selected list of other native animals; if he knows in a practical way what may be done for the maintenance and development of the beneficial members of this group, and for the restraint and destruction of the injurious species; and if he understands and appreciates the public agencies at work and the public operations in progress in the field of zoological economics.

Examining now the assemblage of animals which I have mentioned as available for economic high-school work, we shall readily see that they divide into two principal groups, widely different from each other regarded as materials for study and instruction. In the first group are animals maintained under artificial conditions—the domesticated mammals and birds, fishes bred in confinement, silkworms, bees, and the like—and in the other group are all animals which are economic because of their relations to us and to our interests while living their free lives in their natural environment. To maintain a domesticated animal, a dog, for instance, in health and happiness, we need to know what is good for him in the way of food, medicine, exercise, shelter, hygienic conditions and companionship; and if we are dog-fanciers, desirous of preserving or improving a breed or strain of dogs, for either pleasure or gain, we shall need a practical knowledge of variation, reproduction and inheritance. To catch the wild wolf, on the other hand, we must understand his actions,

powers, habits, haunts, likes and dislikes, and the probable effect of season, weather and day and night on his movements and his enterprises. That is, we need to know, for economic purposes, the *ecology* of the wild animals, and the *physiology* and *thremmatology* of those reared in domestication. This distinction shows us at once that any comprehensive course in economic zoology must be both physiological and ecological.

We shall also readily see that an acquaintance with the *distinguishing characters* of economic animals is absolutely necessary to the economic end. This means, of course, trained observation and a faithful memory. The skilled stock-breeder not only knows the breeds of animals at a glance, and the special uses and values of each, but he has a standard for each breed, an ideal of perfection, and can judge for each individual animal where and how closely it approximates to that ideal, and where and how much it departs from its type; and the young economic entomologist must also know at sight his hundred or so of economic insects, distinguishing them not only from each other, but from all other insects as well. Descriptive zoology is thus an unavoidable necessity for the economic student.

On the other hand, we also readily see that there is little place in our scheme of economic zoology for pure morphology or phylogeny or embryology, and not much for geographical distribution or for theoretical zoology in general. If our high-school course is to become largely economic, these subjects must be left mainly to the college period, must be left out, that is to say, for all except a very few. We must eliminate all the needless and unprofitable part of our present courses, the parts which are of little use in themselves, and which lead to nothing useful or important—the dissection of crawfishes, the physiology of earthworms, the indiscriminate collection of insects—and we must teach those things which are economically useful or which immediately underlie economic utilities.

We must know the laws of variation and heredity which control progressive stock breeding; and such laws of life as explain the food-value of warmth, the milk-value and the fat-value of "the simple life;" the meaning and the composition of the balanced ration; such laws and facts of economics as will enable us to understand the relative cost and values of animal and vegetable food for man in the various stages of his economic and industrial

progress; such as will enable us to see how the largest product may be got from the land with the smallest final loss of its fertility.

We do not need to know, concerning insects, the structure of their tissues, or the facts of their embryology, or their morphological relations to other animals, but we do need to know those facts concerning their structures, their adaptations, their habits, their life histories, and their relations to nature at large, which make them harmful or helpful to man, and especially those which make them subject to our control.

As to the methods of instruction in economic zoology, these will depend, as in most other subjects, almost wholly on the capacities and ideals of the teacher. The subject may be taught didactically, as an exercise in memory merely; or it may be so taught as to tax the powers of observation and comparison to an unusual degree, and to require descriptive and graphic representation, analysis, generalization, inference and experiment, ending in the practical application of results. That is, it may be made a mere information study, justified to the average mind by the practical value of the information given, or it may be made the means of a very considerable training in the processes and methods of science. Using the first method, the teacher will describe and demonstrate and narrate and reason and instruct and give explicit directions for each practical measure—and this is the way in which economic zoology seems most commonly to be taught at present, where it is taught at all. The second method is essentially the problem method. The pupil having access to the necessary facts, will be asked—and assisted if need be—to devise and test measures appropriate to the desired economic end, or to explain and account for the utility, or perhaps the usefulness, of some proposed or accepted procedure.

If it be thought that this problem method, as compared with the method of direct instruction, sacrifices the economic to the scientific end, and makes useful knowledge subordinate to mere mental gymnasium practice, then I should say that no amount of *economic information* is of much use to an unobservant, inaccurate, and irrational man; that *there is nothing in education so thoroughly and permanently economic as the training which will make one observant, accurate, and rational with respect to the facts of his own experience.*

Another topic, the discussion of which we must not omit, is

that of the subdivision and organization of our subject matter. What is the unit of instruction in economic zoology? By unit of instruction I mean that smallest division of the subject which is complete in itself and which may be combined with other like units to constitute the elements, at least, of the subject as a whole. In classification, for example, the unit is the biological species; in morphology it is the structure of an individual; in ecology it is the series of interactions between one individual and some one feature of its environment. In economic biology this unit of instruction is the whole body of knowledge necessary to the utilization or control of one economic species. There is no economic value in an ability merely to recognize all the economic species of my neighborhood on in a knowledge of the mere life histories of them all, but there is a very appreciable economic value in a knowledge of *any one* of these species sufficient to put its services at my disposal, or to enable me to protect my person or property against its injuries. The subject matter must be presented, consequently, not in scraps of one kind of information about one thing and another kind of information about another thing, or of one kind of information about several things, but in masses of all necessary information about one thing at a time. Or if conditions compel a scrappy presentation of the subject, we must be sure that the scraps all finally fit together—and are actually so fitted—to make an orderly collection of completed units.

By this means we shall not only make sure that our instruction is all economic in reality and not in superficial appearance merely, but we shall begin to get, at the beginning, the advantages derivable from all the varieties of mental operation and of practical experience which are contained in the whole subject. To acquire a complete economic knowledge of the army-worm or of the horse involves all the varieties of mental and physical action that it does to get the same kind of knowledge of a hundred injurious insects or of all the animals which have ever been domesticated.

And whenever it is possible to choose, with some latitude, among such units of instruction, these should be so chosen that they will lie well together to build some more important structure. In this way we may reach the larger relations and generalizations, both economic and biological, without which our teaching may

lead to an acquaintance with facts, but can give no knowledge of science.

The several schemes of biological instruction now competing with each other in the secondary school mav be roughly divided into the morphological and the ecological, with physiology intervening between these two and contributing variously to both. Both and all are legitimate and desirable parts of a really comprehensive scheme of high-school biology, but pressure of other interests, usually referred to as lack of time, makes the scheme as a whole impracticable, as a rule, in the secondary school, and we are thus driven to a choice between fractions of a natural unit. If we compare the contents of economic biology as just outlined with those of the various existing high-school courses, we shall see that our subject works more easily into the ecological outline than into the morphological; to teach it would necessitate a mere modification of an ecological course, but the virtual displacement of a morphological one. If I am teaching the ecology of insects I can, without great difficulty, develop my subject at certain points in a way to engraft upon it naturally an economic treatment of certain selected species, and this with no great disturbance of the symmetry of my course, and no injury whatever to its organic unity. If, however, I try to fasten an economic topic to a morphological study, I find that the relation of the two is one of juxtaposition merely, provoking the friction of independent bodies rather than the common movement of one.

In any attempted amalgamation of economic and industrial with scientific biology, I should hope that the economic end would not be allowed to overshadow the educational ends which the teacher of biology now has in view; and indeed it does not seem to me that this is at all necessary. A fact is none the less a fact, science is none the less scientific, because they may have an economic application. No value of any kind is subtracted from a new discovery or from a new method of research if it is some time found that they may be made serviceable to human welfare. The scientific method is none the less useful as an educational agency, but really more so, if it is used in working out an economic problem.

I believe that a biological course may be made, out of materials largely but not wholly economic, which may be taught as directly and effectually to the educational end as is any biological

course at the present time, and which will have an educational value greatly surpassing that of the usual high-school course. Indeed, the very object of intelligent economic teaching is such that the method of that teaching must be more scientific, and the outcome of it must be more educational, than are the object and the method of the ordinary laboratory course of the present time—the type course now so firmly fixed in the high-school curriculum. In an economic course well taught, the student is brought into the most frequent contact possible with the living animal and plant; he is expected to study it primarily and chiefly as a living thing, and his attention is focused strongly on its relations to nature, and hence to the welfare of man. He is taught that his work is virtually wasted if he does not become so acquainted with the objects of his study that he shall always surely know them whenever he sees them, that he shall know when and where and how they are likely to be found, and what they will be doing then and there, and that he shall be able to adapt his knowledge of practical measures for their control to the states and conditions existing at the time and place. Such a student has also learned that he must depend wholly on his own observations, illuminated by the contents of his own memory; that he simply *must* reason clearly and correctly on the facts before him, thoroughly testing his reasonings where they are in the least in doubt, for if he fails in any of these things, the unfortunate consequences of his failure will be inevitably visited upon him.

But teaching is not merely or mainly a matter of instruction. It is still more a matter of influence—the influence of the subject and the influence of the teacher on the life, the character, and the mental attitude of the pupil taught. There remains, therefore, the most important question of all. How will this limitation of the biological course in some directions, and this expansion and elaboration of it in others, affect its influence on the student, and affect the teacher's influence in the teaching of it? There are dangers here which, if we can not find means to evade them, may possibly overbalance any good to be expected from the changes we have proposed.

What will be the influence of the economic aspect which we think of giving to biology, on its sympathetic, its aesthetic, and its unitary aspects? Shall we lose the power and the opportunity to exhibit to our students the kinship of all living things, the

essential unity of life upon the earth, the inclusion of the whole living world under universal law? Can we so combine the utilitarian with the aesthetic view that the charm of nature shall not be dissipated, as is so much of the charm of life? I am inclined to think that we can by being aware and by taking pains.

The primitive human traits which lead to the study of nature are curiosity, imagination, and the love of power. Curiosity, cultivated and indulged, makes in time the scientific investigator; imagination awakened by the observation of nature, makes the poet-naturalist; and the desire for power over the objects and forces of the living world makes the economic biologist. These several faculties are not mutually exclusive, do not, indeed, conflict at all in active operation, but each may aid the others, a stimulus to one arousing all to action. Whether the original motive is scientific, aesthetic, or utilitarian, need make little difference if the natural tendencies of the student are allowed their way.

The teacher may, I think, expect that his pupils' interest will pass over quite easily and naturally from the economic to the scientific aspects of biology, from the scientific to the aesthetic, provided only that the natural movements of the mind are encouraged and provided for. Indeed, in my classes more students go on from my economic into my scientific courses than from the scientific into the economic.

I have left to the last the obvious suggestion that secondary-school biology would be greatly strengthened in the public estimation by the addition of certain economic and industrial features, and I think that the underlying feeling that much of our present high-school and college work is virtually useless to the average student is perfectly well grounded. The life of the ordinary man is divided mainly between his business, his recreations, and his functions as a member of his family and of his social group; between his employments, his enjoyments, and his duties, and any element in education which has no important bearing on any one of these, which increases neither his earning power, his capacity for enjoyment, nor his social utility and effectiveness, is likely soon to disappear from the curriculum. Test our ordinary high-school course in botany or zoology by this rule, test even our college courses by it, and we shall see good reason for a dwindling interest in these subjects; we shall see the best of reasons for a

vigorous effort to strengthen our courses on the practical side, especially since by intelligently doing this we shall also strengthen them on the scientific side.

Permit me, finally, to close this mere introduction to the discussion of our subject by a brief summary of the principal suggestions thus far made.

1. To give an economic aspect to secondary-school biology, the biological course must be largely modified by the introduction of economic materials and by the use and teaching of the scientific method.

2. Biological materials to be economic must be applicable, must be actually applied, to the promotion of the economic welfare of the individual and of the people at large.

3. To apply economic materials to his own welfare the individual must see and understand the economic factors of his own environment, must know the means to the economic end, and must reason correctly and act efficiently in the application of these means to the end desired.

4. To apply biological knowledge to the general welfare the individual must know what biological materials are of general economic value, and what general and individual action is necessary to their economic use and application. He must know and do his social and political duty in this regard.

5. Zoological materials of a sufficient economic value to entitle them to consideration in the secondary school are mainly to be found in the biology of the domesticated animals and that of injurious and beneficial insects, birds, and fishes, with a small selected list of other animals.

6. The kinds of zoological knowledge economically applicable are, first, an acquaintance with economic families, genera, species, varieties, breeds, and strains, sufficient for their certain recognition, and, second, a knowledge of the periods, activities, habits, products, and ecological relationships of the economic animals which make them economic, and especially of those facts which indicate and determine practical measures for their economic utilization and control. Besides a recognition acquaintance with the economic forms, this necessary knowledge is mainly ecological and physiological, ecology predominating in the zoology of the injurious groups, and physiology (including thremmatology) in that of the domesticated animals.

7. The kind of scientific training necessary to make such zoological knowledge practically economic, practically applicable to the individual welfare, is training in observation, recollection, analysis, inference and experiment. An economic course must be strongly scientific, for the method of science is economically more important than any scientific facts.

8. The high-school course which shall meet these requirements must be different from any now commonly taught. It must be a composite of a biological and an ecological course, with morphology mostly omitted, and with instruction, training and practice in the method of science carried to the limit of time and opportunity. It ought to make a strong, good and popular course —one whose practical utility, directly as this is aimed at, will not surpass its value as an element in scientific education.

9. If I were to undertake to apply these suggestions in a secondary school, I would modify the existing course, of whatever kind it might be, by the gradual introduction of economic elements, feeling my way experimentally, and proceeding only so fast and so far as the results should justify. I would do this, however, with careful reference to what I have called the unit of instruction, making sure that these economic elements were incorporated into the course in complete and unbroken units, to the end that the full benefit of the innovation might begin to appear from the very first, and I would do my best that no really material element of a liberal preparation for the life of an educated man should be sacrificed to the economic advantages aimed at, but would seek to apply faithfully that fundamental principle of all rational progress, "to prove all things," whether old or new, "and to hold fast that which is good."

DISCUSSION.

By Miss Rousseau McClellan,
Shortridge High School, Indianapolis.

The question before us is whether we wish to study plants and animals with reference to their value for the purposes of man. We need to get away from the old idea that everything centers about man. We must decide our question from the standpoint of the high-school teacher and his opportunities. There is relatively little time given to the study of biology in secondary

schools. In Indiana zoology is usually an elective subject, if offered at all. In Illinois it is more generally required for graduation, and the course usually covers one year. Botany receives about the same amount of time. If we remember also the age of the high school boy or girl who does the work we can, perhaps, judge whether it is wise to make the economical phase of biology the basis of the course. Suppose we study useful or harmful forms exclusively. The impression would be left that biology is of importance only when studied with reference to the needs of man.

Another question that confronts us is whether boys and girls of the high school age could work out economical problems with their limited information. We often hear that zoology, especially, is not interesting as now taught. It is certainly easy to awaken interest in insect-eating birds, either in the city or the country, by explaining their value to man, or to introduce the study of insects with a few statements in regard to the insect destruction of field crops. The boy in the city needs something entirely different from the country boy to arouse his enthusiasm. The courses most approved today include a knowledge of the structure, physiology and ecology of types of the great groups. Ecology cannot be taught without some knowledge of structure, neither can economical biology. It certainly seems wise to begin our work in a logical way with the study of a simple alga or protozoan, thus giving a clear conception of the simple forms and making less difficult the study of the more complex.

The economical and industrial phase of biology, if emphasized, will add interest, but is not adapted to form the basis of a course in zoology or botany for most schools.

DISCUSSION.

By Thomas Large,
Oak Park Township High School.

From a biological point of view, the high school period of education is, more than any other, recapitulatory—at this time the youth is learning the things of worth which the race has learned, or he is acquiring the intellectual furnishing which shall make him as nearly as possible equal to the mature man. Because the idea of organic evolution dominated the thought of the past century

morphological courses were organized to teach this great principle. The teacher has become interested in the purely theoretical side of the subject and has neglected its application to the betterment of economic or sanitary conditions. In teaching the biogenetic law it should be shown in its application to water supply, sewage disposal, quarantine regulations and various other things. We must not be content with illustrating parthenogenesis in our study of plant-lice, but must see their relatives and their relation to horticulture and to their enemies. It will not be amiss to make our ecological studies among animals known to have an economic bearing.

The great question, however, which the paper raises is, "Shall we ignore all but the economic phases?" It is the old question, "Shall we teach how to make a living or to live?" This is at the bottom of the civic side of our work. If time which may be given to biology only suffices for this kind of work, then it should be done to the exclusion of the other, or the time should be increased. It seems, however, that sufficient time is now generally allotted to the subject to give it a wider outlook and to introduce illuminating materials. An outlook which shall cure the student of that barbaric idea that everything to have an excuse to exist should be good to eat. An outlook which shall prepare him to assimilate the new ideas which shall come to him as years go by and new things of economic or philosophic importance are brought to him. We are not ready to abandon the morphological course entirely, for it has an important function.

The practical or economic, however, offers fine illustrative material and has the value of being within the grasp of all, thus providing elasticity to the course. The dullest boy will not fail to grasp the significance of grafting or budding, though he would never grasp in terms that the bud was the portion of the plant which bears the inheritance.

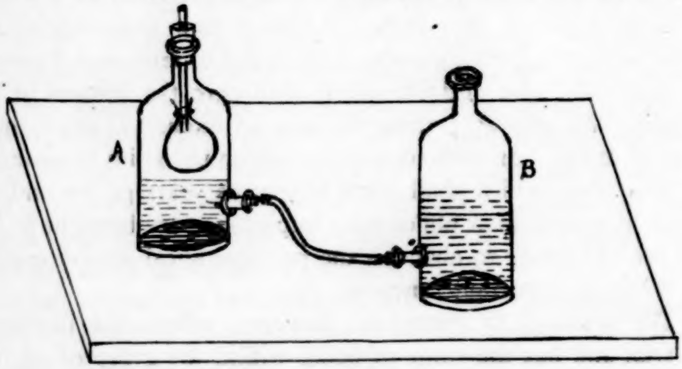
As our courses in biology are now largely elective, for students generally those subjects which seem a part of the essential equipment for citizenship might well be introduced as a part of our elementary science courses which are now finding place in the first year of the high schools.

The National Educational Association will meet at Asbury Park, N. J., July 3-7. President, Superintendent William H. Maxwell, New York City; Permanent Secretary, Irwin Shepard, Winona, Minn.

A DEVICE SHOWING THE MECHANISM OF RESPIRATION.

BY G. C. BUSH,
Marion, Ind.

While studying air pressure recently the writer asked a class what caused the expansion of the lungs in breathing. Fully three-fourths of the members thought that the expansion was due to air that was forced into the lungs by some part of the respiratory organs above the trachea. All of these persons had in mind some kind of pumping apparatus whereby the air was drawn into trachea and passed on into the lungs, causing its expansion and the accompanying upheaval of the chest. Other classes were asked the same question. Again a large majority gave the effect for the cause. To make clear the mechanism and phenomenon of respiration, the writer devised the apparatus shown in the accompanying figure, which explains itself. Two aspirator bottles are connected

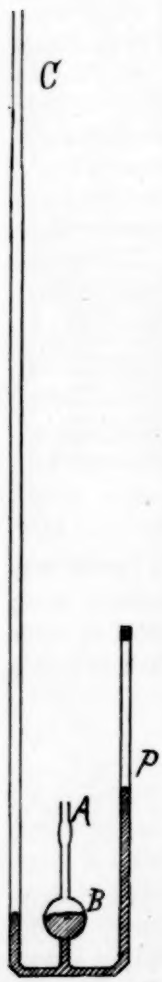


by rubber tubing. Through the stopper of bottle *A* a glass tube is passed, and terminates in a rubber bag which corresponds to the lungs. The surface of the watter in bottle *A* corresponds to the diaphragm and can be raised or lowered at will by elevating or lowering bottle *B*. The rubber bag responds rapidly to the change of water level, and regular expansion and contraction can be shown. The writer believes that this device is simpler and truer to the anatomical mechanism than the method of exhausting the air from a bell jar containing a rubber bag in connection with the outside air. With it pupils in the grades could get a notion of the breathing phenomenon which would not have to be corrected later on.

APPARATUS TO ILLUSTRATE BOYLE'S LAW.

BY H. L. CURTIS,

Instructor in Physics and Electrical Engineering, Michigan Agricultural College.



The apparatus sketched possesses certain qualities which are desirable in any apparatus to be used in the laboratory in the proof of Boyle's Law. It is convenient, does not bring mercury in contact with rubber tubing, can readily be made air tight, and does not require a skilled glass-blower to construct.

Secure a bulb tube. Seal this into a long glass tube of uniform bore, about one-fourth of the distance from one end. Bend this tube at a right angle on each side of the bulb, so that the two arms and the bulb lie in the same plane. A piece of glass rod, cut square at the lower end, may be sealed into the end of P, or, better still, it may be cemented in with Canada balsam. Mercury is then introduced through A, and if it is desired to use pressures less than one atmosphere, P may be slightly heated, provided care is taken not to heat it near the plug. A piece of rubber tubing (not shown in the cut), having a bicycle valve cemented in one end is securely fastened over A. The whole is fastened to a vertical board. A scale is placed beside each tube, or still better, a mirror scale is placed behind each tube.

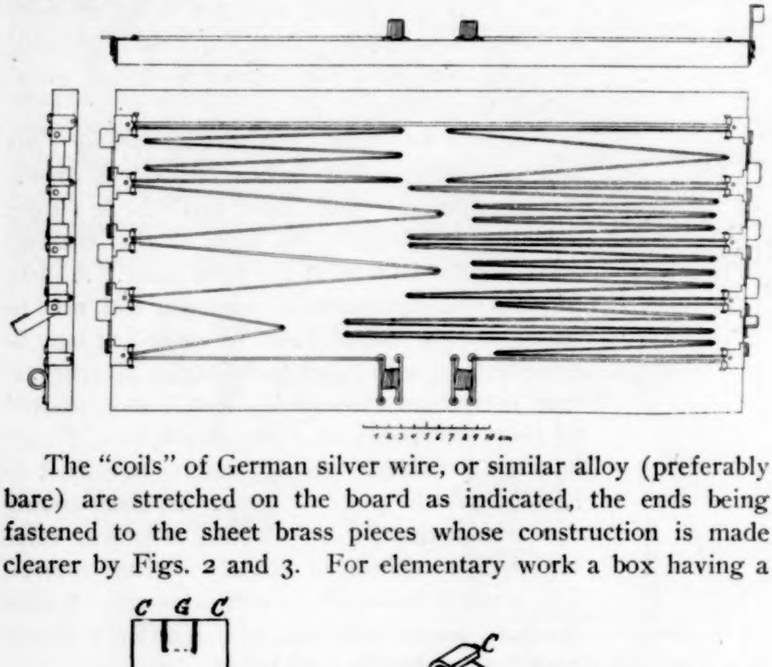
A small bicycle pump is used to force air into B. This will increase the pressure in P, and this pressure may be determined by the difference in the height of the two mercury columns plus the atmospheric pressure. The volume of air is proportional to the distance between the mercury and the plug in P, if the bore of the tube is uniform.

This apparatus is made on the same principle as a piece devised by Mr. N. H. Wilkinson of the Western High School, Detroit. A description of his apparatus may be found in the Proceedings of the Michigan Schoolmasters' Club for 1899.

A SIMPLE RESISTANCE BOX.

BY ARTHUR W. GRAY.
Leyden, Holland.

A resistance box which is not only very cheap but also very accurate can be easily made of material which should be found in every physical laboratory: a board, some wire, some sheet brass, a few nails, and a bit of solder. Fig. 1 represents it in orthographic projection.



The "coils" of German silver wire, or similar alloy (preferably bare) are stretched on the board as indicated, the ends being fastened to the sheet brass pieces whose construction is made clearer by Figs. 2 and 3. For elementary work a box having a

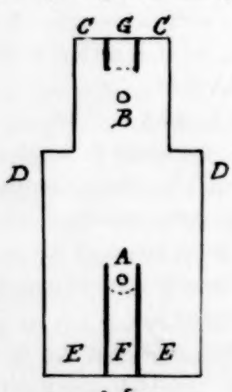
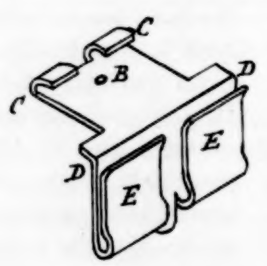


Fig. 2.



Isometric Projection

Fig. 3.

range of from 0.1 ohm to 11 ohms is convenient: 0.1, 0.2, 0.2, 0.5, 1, 2, 2, 5, ohms. The wires for these should be so selected that no coil shall be shorter than about 50 cm., and to avoid clumsiness it is better to have none longer than about 200 cm. In some boxes which the writer constructed several years ago while teaching in California three sizes of wire were used, whose diameters were 0.32, 0.46, 0.82 mm., for which one ohm required approximately 37, 87, and 243 cm. respectively. It would, however, have been better to use a still larger size for the 0.1 ohm coil, so that it would be longer.

For most purposes it is not essential that the coil labeled one ohm should be accurately of that resistance; but it is important that it should have one-fifth the resistance of the one marked 5 ohms, ten times that of the one marked 0.1 ohms, etc. To attain this agreement of the coils among themselves, the length of the wire for any one of them (say the 2 ohm one) is determined, preferably by direct comparison with a known resistance; but when none is available, by comparison with a piece of copper wire, whose resistance can be calculated with sufficient accuracy from its dimensions; and then, by direct comparison, the sizes of the other wires are found that have the same resistance as the standard thus selected. The length required for each coil can now be calculated; and even if a coil is as short as 50 cm., an error of 5 mm. in measuring the length used will make a difference of only one percent.

The lengths of the coils determine the size of the board necessary for conveniently mounting them. It need not exceed 25 by 50 cm.

The terminals of the coils are made of spring sheet brass about a millimeter thick and of a quality that will stand bending double without cracking. A piece of the shape shown in Fig. 2 is cut out and is slitted as indicated by the heavy lines. The holes A and B can be punched with a piece of steel wire if the brass is laid on a block of lead; or they may be easily drilled. The end CC is softened by heating to dull redness and cooling in water, and then the whole is scoured with emery-paper before bending. The first bend is a right-angle at DD; then the pieces EE are bent up as indicated in Fig. 3, a bit of wire about 2 mm. in diameter being temporarily placed in the bend when it is about half completed to facilitate giving it the proper open shape, so that it will form a

strong spring. Then the portions CC are bent over into hooks to clasp the wires, F and G trimmed off at the dotted lines, and the sharp corners rounded off with a file. Six of these pieces are prepared, and in addition four with only one spring, E, to be used at the corners of the board, as shown in Fig. 1.

Half of these terminals are equidistantly spaced at each end of the board and fastened by nails through the holes A and B. The ends of the wires, bent twice at right-angles, are placed in the hooks C and secured by pinching the brass against them with pliers. To make good contact, they are finally soldered after the wires have been stretched and held in place by nails, tacks, or staples at the bends. The "plugs" may be merely pieces of sheet brass to be firmly clasped by the springs E; but the switches represented in Fig. 1 are quickly made and have the advantage that they cannot be lost. After these have been cut out and bent into shape, they are placed in the springs E. Then the holes for the pivots, which are wire nails or screws, are drilled. The firm clasping of the springs E is relied upon for contact; the nail pivots are merely to prevent the switches from coming out; so in bending one of the former, care should be taken to have the entire flat surface bearing well against the switches when inserted. Thick copper wires or strips unite the two sections of the resistance box and lead from the ends to the spring "binding-posts." In making these a long closed spiral of hard-drawn brass wire from 1.5 to 2 mm. in diameter is first wound on a rod and then cut into sections long enough to allow for the spring and for what must be straightened and afterwards bent into shape for fastening to the board with nails or screws. This form of terminal is not only easily made, but also has the advantage that the act of inserting the wire polishes the contact.

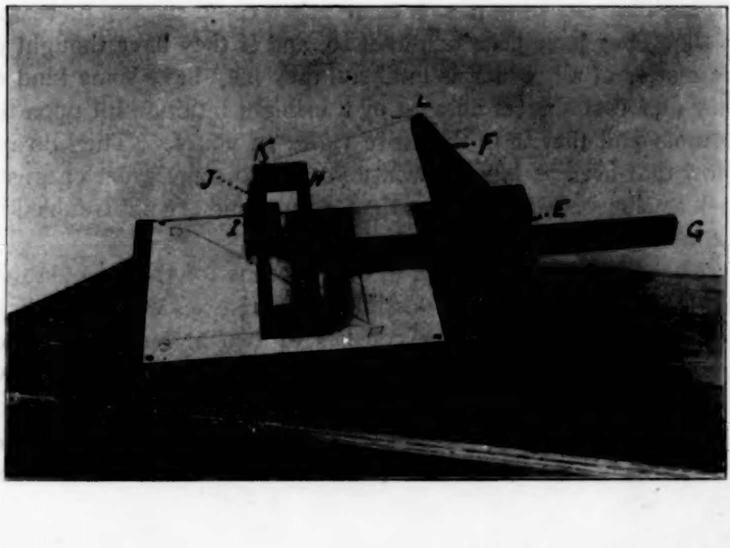
With the exercise of a little care a resistance-box of this type can be made very accurate. If the springs E are stiff and bear well on the switches, the contact resistance will be small, especially since the opening and closing abrades the surfaces somewhat and keeps them bright. The wires connecting the two sections with each other and with the spiral springs can be reduced to a minimum by mounting each section on a separate board and then fastening the two boards together with cleats in such a way that the switches face each other with only a few centimeters between them to permit their manipulation. Then, if the wires are made a

trifle longer than calculated, they may be finally adjusted by adding a little solder, as is done in adjusting expensive boxes. To eliminate as much as possible the resistance of the switches, one should adjust separately each wire, except the second 0.2 ohm, so that when the switch for short-circuiting it is the only one open, the total resistance between the spiral spring terminals is that marked for the wire. Then the second 0.2 ohm should be adjusted to give 0.3 ohm when combined with the 0.1 ohm. This makes it possible to eliminate the resistance of the switches in obtaining any number of tenths of ohms except six, eight, or nine, when the resistance will be too small by that of one switch. The second 2 ohms can, of course, be adjusted in the same way, though with the units this is hardly worth while, as the resistance of one or two switches causes only one-tenth the proportional error caused with the tenths. For the purposes of elementary work these refinements are, however, entirely unnecessary.

PARALLELOGRAM OF FORCES APPARATUS.

FRED A. HOLTZ,
State Normal School, Mankato, Minn.

This is a convenient piece of apparatus to illustrate the action of concurrent forces at right angles. It is very simply constructed out of wood. A vertical post, E, is fastened to the base board. It carries a horizontal arm, F. The handle, G, slides through E, and



carries the cross arm, H. A block, I, slides on this cross arm. The pencil, J, passes through a hole in the block and is held against the paper by means of an elastic band fastened to a hook on the block. The sliding block, I, moves by means of a cord fastened to it, and passing through a screw-eye at K and attached at L.

To operate, draw handle back and move slider, I, to A. Take in slack of the string. Then push handle forward and the block is at same time drawn along the arm, describing the resultant of the two motions of the block.

THE FORMULA OF WATER.

By John Waddell,
School of Mining, Kingston, Ont.

A friend of mine was asked by a young man if he would tutor him in chemistry in preparation for an examination. "How much do you know about chemistry already?" said my friend. "Absolutely nothing," was the reply, "except that HO_2 is water." I will venture to say that nine out of ten (perhaps even ninety-nine out of a hundred) of the pupils studying chemistry in our high schools, and I might include the junior classes in our colleges, though they would laugh at the mistake of saying HO_2 instead of H_2O, could give no satisfactory reason for preferring the latter formula to the former.

The majority of pupils on being asked could suggest no reason at all. They have been taught it so, and if they have thought of the matter at all, which is unlikely, they may have some kind of hazy idea that a great chemist by a brilliant intuition hit upon the formula and that it is therefore right, of course. They do not know that even as late as twenty years ago some great chemists, such as Bunsen, wrote HO as the formula, and are not troubled by a conflict of authority.

Other pupils will attempt to give reasons for the formula they employ. Among the most sensible of the reasons will probably be that the molecule of water consists of two atoms of hydrogen and one atom of oxygen, or that the electrolysis of water gives two volumes of hydrogen for one of oxygen. But in the first reason the fact is overlooked that not only have we never seen atoms or molecules, but we can never hope to see them. Our ideas of atoms

and molecules are deductions from observation and experiment and instead of the argument proceeding from the premises of atoms and molecules to the formula the argument should go from experiment to the formula, and the accompanying deduction that the molecule of water contains two atoms of hydrogen and one atom of oxygen.

The argument from the electrolysis of water is based on experiment and is to a certain extent good, but it is not conclusive because it is possible that the quantity of hydrogen represented by H would occupy twice the volume of the quantity of oxygen represented by O. Carried out consistently, the argument would lead into error in some cases. Ammonia, to which the formula NH_3 is given, decomposes into three volumes of hydrogen to one of nitrogen, but, on the other hand, phosphine, to which the formula PH_3 is given, decomposes into one and one-half volumes of hydrogen to one of phosphorus.

There are two arguments in favor of the formula H_2O that can be easily followed by the junior student; one is entirely experimental, the other involves a short train of reasoning.

The first argument is based on the decomposition of water. When water is decomposed by the electric current, all of the hydrogen separates at one pole and all of the oxygen at the other. Also when steam is decomposed by red-hot iron all of the hydrogen is set free and all of the oxygen is retained by the iron. But when sodium acts on water all of the hydrogen of the decomposed water is not set free—half of it only is set free; the other half, together with all of the oxygen, unites with the sodium and when the water that has not been acted on is evaporated by heating the solution, a white substance, caustic soda, consisting of sodium, oxygen and hydrogen, is left behind, the amount of hydrogen in the caustic soda being equal to the amount that was set free. The hydrogen in caustic soda may be liberated by fusing the caustic soda with additional sodium, sodium oxide being formed at the same time. This experiment shows that the hydrogen of water can be divided into two equal parts. The oxygen of water has never been divided. In every operation in which oxygen is taken from water all of the oxygen holds together. The simplest way of representing these facts is by the formula H_2O, for this shows the possibility of separating the hydrogen into two parts and indicates the impossibility of dividing the oxygen.

The second argument is based on Avogadro's Law, and is a little more theoretical than the first. Avogadro's Law is that equal volumes of different gases, under the same conditions of temperature and pressure, contain equal numbers of molecules; that is, if a certain volume contains 100,000,000 molecules of hydrogen it would contain 100,000,000 molecules of nitrogen, or ammonia, or marsh gas, or water vapor. We do not know the volume of 100,000,000 molecules, and we cannot adapt our volume to contain any specified number of molecules. But we can choose a liter as our standard volume, and if Avogadro's Law is true a liter would contain the same number of molecules of every gas and the weight of a liter of the different gases would give the relative weight of the molecules. A liter of hydrogen weighs .09 grams, a liter of nitrogen fourteen times as much, of ammonia eight and a half times, of marsh gas eight times, and of water vapor nine times. But these numbers, which would all be fractions, are not very convenient and have no very evident connection with the formula of the gases or with the weights of the various constituents of the gases, and instead of taking a liter of hydrogen as the standard, it might be better to take the volume of hydrogen that would weigh a gram. This volume is a little over eleven liters and it contains 14 grms. of nitrogen, 8½ grms. of ammonia, 8 grms. of marsh gas and 9 grms. of water vapor. The same volume would contain 18.25 grms. of hydrochloric acid, of which one-half gram would be hydrogen and 17.75 grms. chlorine.

If possible, however, it is best to adopt such a standard volume that the formula will represent volume as well as weight. It has not been found possible to decompose hydrochloric acid in any way so as to divide the hydrogen into two parts or the chlorine into two parts, and hence the most satisfactory formula is HCl. If we are to make the formula represent grams we have the gram formula weight, or, as it is usually called, the gram molecular weight. The symbol H must then stand for one gram of hydrogren and the symbol Cl for 35.5 grams of chlorine. Now, 36.5 grams of hydrochloric acid occupy the volume 22.4 liters (approximately), so this volume is the most convenient to use.

There are many gaseous compounds of hydrogen, and not one of them contains less than a gram of hydrogen in 22.4 liters. A number contain exactly one gram, some two, some three, some four, etc. In the same way the volume 22.4 liters contains

35.5 grams of chlorine, or some whole multiple of 35.5 grams, but never less. Similarly, no compound of oxygen in the gaseous condition contains less than sixteen grams of oxygen, no compound of nitrogen less than fourteen grams of nitrogen.

If, then, 22.4 liters be taken as the standard volume, the weight of the various elements that it contains will be once, twice, three times, or some other multiple of the atomic weight. Twenty-two and four-tenths liters of ammonia contains 14 grams of nitrogen, and as no gaseous compound of nitrogen contains less than fourteen grams in this volume, it is reasonable to represent fourteen grams by the symbol N. There are three grams of hydrogen in this volume of ammonia, and so ammonia is represented by the formula $N.H_3$. Water vapor contains two grams of hydrogen and sixteen grams of oxygen in 22.4 liters. No compound of oxygen contains less than sixteen grams of oxygen in this volume, hence the formula of water is written H_2O. If any new gas was discovered containing eight grams only of oxygen in 22.4 liters, eight grams would require to be represented by the symbol O, and the formula of water would be H_2O_2. Hitherto no such gas has been discovered, and it would be strange if among all the compounds known none should have the minimum quantity of oxygen.

Expressed in terms of the atomic hypothesis, it would be strange if among all the compounds of oxygen known, none should have less than two atoms of oxygen in the molecule, and still further that none should have an odd number of atoms. It is hoped that this article may be of use to teachers in their endeavor to help pupils to understand the real meaning of chemical formulæ.

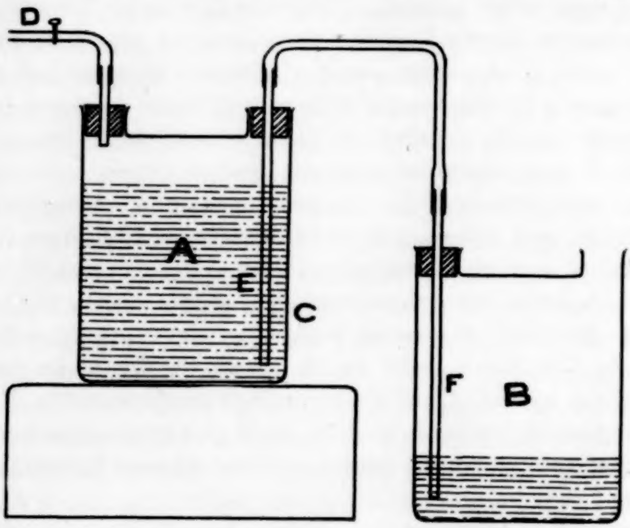
APPARATUS FOR TRANSMITTING GAS FROM ONE VESSEL TO ANOTHER.

By J. A. Griffin,
Collegiate Institute, St. Catharines, Ont.

The teacher of chemistry frequently finds it necessary to use small quantities of pure gas for experimental purposes. Having prepared a small quantity of gas he often finds it difficult to transfer the gas from one vessel to another without mixing it

with air. To overcome this difficulty the apparatus described in this paper has been used with good results. It is simple and easily prepared, the gas can be easily controlled and any pressure may be obtained to transfer it from one vessel to another.

The accompanying diagrams, 1 and 2, will fully explain the method. A and B are two Wolff bottles fitted with perforated



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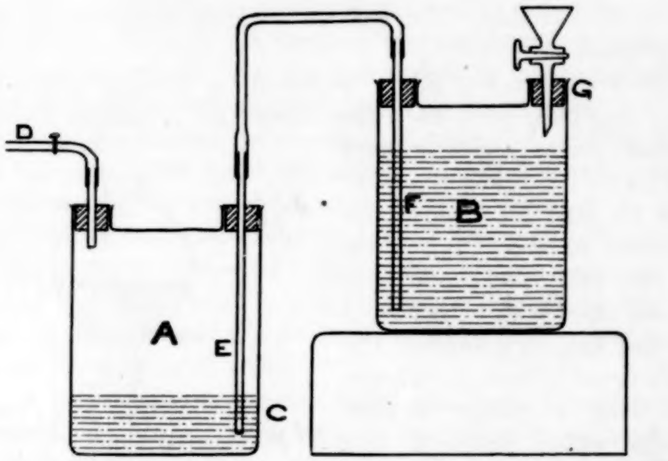
rubber stoppers having two pieces of glass tubing, E and F, passing to the bottom of the jars and connected, outside, by rubber tubing. If Wolff bottles are not available any large bottles with wide mouths and fitted with double perforated stoppers will do. Fill A with water or other liquid which will not absorb the gas. Arrange as in Fig. I. Leave the neck, G, open. Connect D with the gas generator. Raise A above B so as to diminish the pressure in driving the liquid from the vessel A to B. Open the stopcock or clamp at D. The liquid in A passes into B through the tubes E and F. Do not force all the water out of A, but leave enough to cover the bottom of the tube E as far as C. Close the clamp D and disconnect from the generator. Connect D with drying tube and then to the vessel to be filled with gas. Fill or nearly fill B with water. Place B above A. Put a funnel with glass stopcock in G and make the stopper air-tight. The apparatus will now be arranged as in Fig. 2. Greater pressure can be ob-



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tained by having a long funnel in G. Now open the clamp at D and the stopcock in the funnel. The liquid in B will pass into A and the gas in A will be forced where desired. By closing the stopcock in the funnel the pressure is removed and the gas ceases to pass out of A.

If sufficient pressure cannot be obtained in this way, a glass tube may be placed in the stopper in G and this connected with a rubber bulb such as is used in an ordinary atomizer. Very great pressure may be obtained in this way.

AN IMPROVED PORTABLE GAS GENERATOR.

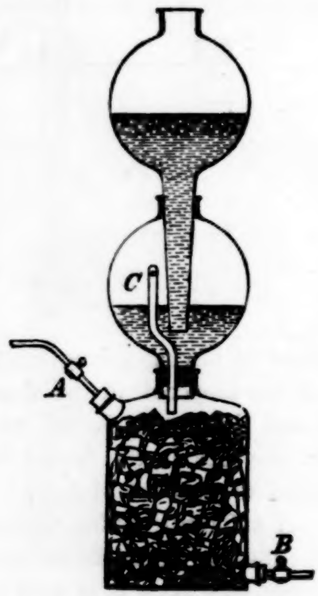
By Herbert N. McCoy,
University of Chicago.

The great number of gas generators described in the literature is good evidence that a wholly satisfactory form has not yet been produced. The popular Kipp apparatus has two serious defects, which are only too well known: (1) on account of imperfect circulation of the solution the action stops long before all the acid is exhausted; (2) the apparatus must be completely emptied at each addition of fresh solution. The two defects have been completely overcome in Ostwald's generator.* The latter gives highly satisfactory results as a stationary apparatus, but it is not compact,

* Ostwald, Principles of Inorg. Chem., 270 (1902).

nor readily portable. The wooden or metal supports are also objectionable.

The accompanying figure represents a portable generator, having only glass parts and rubber stoppers. It consists of three principal pieces with ground glass joints. The lower part, in which the solid is contained, has a capacity of about two liters. The two side tubulures of this part are fitted with rubber stoppers and stop-cock tubes. The middle vessel is fitted, at its lower end, with a rubber stopper through which passes a bent glass tube, C, of about 0.8 cm. internal diameter. Near the upper closed end of this tube is a small hole, F, 1.5 mm. in diameter.



The principle on which the apparatus acts is the same as that of the Ostwald apparatus. On opening the stop-cock, A, gas escapes. The acid flows from the upper into the middle vessel until it reaches the small hole in the outlet tube, C, when it runs *slowly* onto the solid in the lower compartment. The tube, C, is made large enough to avoid capillary action. On account of the great surface of the solid, over which the acid solution flows, the reaction takes place very rapidly; there is, consequently, but a very small amount of unused acid in the lower compartment at any time. After closing the stop-cock, A, the gas generated by the action of the small excess of acid in the lower vessel escapes into the middle vessel and thus forces part of the acid into the upper reservoir. The volume of gas so generated is usually much less than 100 cc.

The spent liquor should be drawn off through the tube, B, whenever it has accumulated to a depth of 3 or 4 cm. Fresh hydrochloric acid (1:1) is to be added to the upper reservoir as needed. The lower vessel must be kept well filled with solid to get the best results.

The apparatus is continuous in action and completely exhausts all of the acid used. It has been thoroughly tested, with highly satisfactory results, for the generation of hydrogen sulphide, hydrogen and carbon dioxide. In generating carbon dioxide the action of the acid on the marble is so rapid that the tube, C, may be left open at the upper end without danger of a great excess of acid entering the lower compartment. The action of the acid on pure zinc or on ferrous sulphide being considerably slower, it was found better to somewhat limit the flow of acid by means of the closed tube with a small hole, in the manner described. When pure zinc in sticks is used it is advisable to add a little copper sulphate to the first charge of acid.

A very simple device (not new) which can be highly recommended consists in placing between the generator and wash bottle a constricted tube or capillary which limits the flow of gas to a certain maximum. This not only prevents a waste of gas, but also gives a more uniform stream. The new gas generator may be obtained from Bausch and Lomb, Chicago.

NOTE ON ETCHING WITH HYDROFLUORIC ACID.

BY NICHOLAS KNIGHT,
Cornell College.

In the interesting and practical experiment of etching on glass with hydrofluoric acid, it is desirable to have the entire surface coated with a uniformly thin layer of wax. To obtain this result, the writer for a number of years has kept an ordinary copper steam bath, six inches in diameter, nearly filled with paraffine. This is carefully heated to avoid burning until it is all melted. The glass object to be etched is immersed in this liquid and quickly withdrawn, when both sides are uniformly covered with a thin layer. The etching is so satisfactorily accomplished that many times the students are desirous of repeating the experiment, and they etch beautiful designs on various articles, watch crystals, paper weights and similar objects. Thus they have a perpetual reminder of the days spent in the fascinating realms of experimental chemistry.

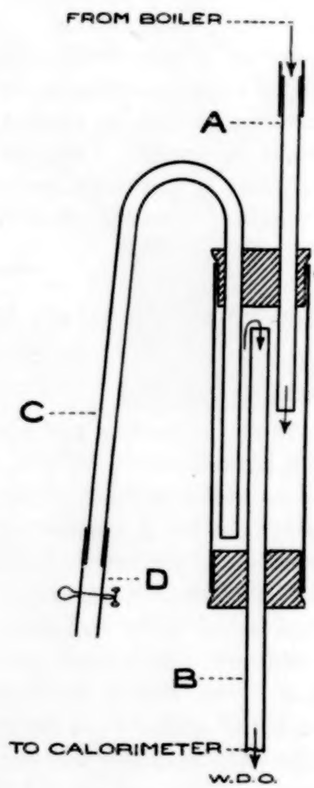
AN IMPROVED FORM OF "STEAM TRAP."

BY WILLIS E. TOWER,
Englewood High School, Chicago, Ill.

A satisfactory "steam trap" for use in experiments in heat removes a serious source of error in determining the latent heat of vaporization of water, and in other experiments in which steam, as free as possible from water of condensation, is desired.

The apparatus shown in the drawing represents a "steam trap," in section, which contains the following features:

(a) An outlet tube, B, with a minimum of surface exposed to the air between the "trap" and the calorimeter. (b) A siphon device, C, which enables one to draw off the water accumulated in the bottom of the "trap" at any time during the progress of the experiment.



To construct the trap take a 12 cm. length of glass tubing 2.5 cm. in diameter. Round the ends in a flame and fit to the ends a one-hole and a two-hole rubber stopper, respectively. Through the one-hole stopper pass tube B, which extends from near the top to some 15 cm. below the bottom of the trap. Through the two-hole stopper pass, first, A, the lower end of which must extend below the top of B; second, the siphon C, a glass tube, fitting one of the holes of the stopper and bent as shown, with its outer end lower than the end within the large tube. This outer end is fitted with a short length of soft rubber tubing, which is closed with a pinch cock.

In first using the apparatus, before placing B in the calorimeter, remove pinch cock at D and close lower end of B till a good jet of steam issues from D; now open end of B, replace pinch cock at D and the apparatus is ready for use. The advantage in having air driven out of the siphon by steam is that as fast as water accumulates in the bottom of the trap it is automatically driven over to the outer arm of the siphon until the latter is full. This latter action is caused by the pressure in the outer arm being lowered by steam condensing there. For the best results the inner end of the siphon should be within 2 mm. of the bottom of the trap.

Terrestrial Magnetism. The results of the magnetic observations made by the United States Coast and Geodetic Survey, department of commerce and labor, Washington, D. C., between July 1, 1903, and June 30, 1904, are contained in a pamphlet issued as an appendix to report No. 3, for 1904, on terrestrial magnetism. It is edited by Dr. L. A. Bauer. It describes the new type of instrument which is in use, and discusses the methods of observing and the general accuracy of the results. Stations located in twenty-four states are described.

MEETING OF THE MATHEMATICAL ASSOCIATION OF WASHINGTON.

The second annual meeting of the Washington Mathematical Association, held in Spokane upon Dec. 29, 1904, was a decided success. A large number of teachers, representing every part of the state, were present, and enjoyed a strong program dealing with the various mathematical questions of the day.

The regular meeting of the San Francisco section of the American Mathematical Society was held on Saturday, February 25, at Stanford University, the first session opening at 11 a. m. and the second session at 2 p. m.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

DEPARTMENT OF METROLOGY, NOTES.

Metric System Popularized. No one thing shows the increase of popular interest in the metric system so clearly as the constant use of its terms in current literature. In the reading room of a large public library, in a section where weekly and monthly journals of a semi-popular and scientific nature were kept, we one day picked up, without discrimination, the last issue of nine of these periodicals, English and American only, varying from the *Scientific American* to the *Street Railway Review,* but not including strictly technical journals. In eight of these nine occurred some terms of metric measurement, the exception being a western mining paper, and even this contained degrees of the centrigrade scale. Thus is the world's system being forced upon the notice of all who read.

Even the daily press, in its efforts to keep up with international usage, has often to record meters and kilos. In the Olympic games, held last summer in St. Louis and open to the world's competition, metric measures were used side by side with our antiquated ones.

Hastings' *Manual of Physical Measurements, with Anthropomorphic Tables,* just issued by Macmillan, gives measurements of the various parts of the body in both English and metric terms. Ridgeway's large work on *Ornithology,* which has been in progress for several years, was changed at the last moment from English measures to metric. R. P. W.

Yarn Count in the Metric System. In view of the fact that one of the great storm centers of metric opposition is the textile industry, led by Editor Dale, whose screeds against the metric system appear in almost every issue of the *Textile World Record,* interest attaches to a letter in the *Lowell Textile Journal* for January, 1905, from the large yarn house of M'Lennan, Blair & Co., Glasgow, Scotland. Mr. Blair states that when he issued his first "Comparative Yarn Tables," in 1883, he said that "if a system was to be introduced it ought to comply with six conditions, namely: 1. It must be decimal. 2. It must indicate length to weight. 3. It must be equally convenient for the spinner, dealer and manufacturer. 4. It must be adapted to every thickness of yarn. 5. It must be adapted to any number of folds, excentric loop and knop. 6. It must be written so as no mistake could be made." He further says: "The International Metric System of Count is now (1904), I think, as nearly perfect as anything can be." R. P. W.

REPORT OF THE COMMITTEE ON THE SO-CALLED TEMPERANCE PHYSIOLOGY MADE AT THE ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, NOV. 30, 1904.

The chairman of this committee finds himself in the unfortunate position of being considered an enemy of both temperance and intemperance at the same time. A year ago the committee, of which I have the honor of being chairman, presented some resolutions, one of which reads: "We believe that the method of presentation required by these laws makes such teaching detrimental to the best interests of both education and temperance." We immediately lost caste with the "W. C. T. U.," and were accused by some of being in collusion with saloon interests. Since then a swarm of bees escaping from my apiary took up its permanent abode in the wall of a saloon just above the front door, much to the discomfort of would-be patrons and the proprietor. Dire threats have been made to compel me to remove the intruders, and evil reports have been circulated among the patrons of the saloon to show that I am undesirable as a neighbor, selfish and hostile to the general interests of the community in which I have lately taken up my abode. Being therefore considered an enemy to both sides, I shall freely speak my mind.

In order to understand the position of the friends and opponents of Temperance Physiology it will be necessary to give a brief outline of the movement.

Mrs. Mary H. Hunt of Boston presented to the National Committee of the W. C. T. U. in Indianapolis in 1879 her scheme of approved text books and compulsory study in the public schools. She was at first made chairman of a standing committee, then National Superintendent, in 1888, and finally International Superintendent.

Now every state but Georgia has a temperance physiology law varying in stringency from a mere mention of the subject to be taught, as in Massachusetts, to an intricate system by which each officer in the school system is made to watch and report under oath all violations of the law before any money can pass through his hands to those who conduct the work of the schools below him. Severe penalties are imposed upon all violators of the law. Even the innocent teachers suffer with the guilty by having the revenues cut off till the law has been satisfied. This is the law of New York state.

Massachusetts, one of the first states to pass a temperance physiology law, simply requires the study to be taught as other branches are. In 1899 a great effort was made to pass a more stringent law similar to that of New York (1896).

Fourteen years after the beginning of this movement "The Committee of Fifty" was organized to investigate and report upon various aspects of the Liquor Problem. A mere mention of the names of a few of these men is a sufficient guarantee of the fairness and reliability of their work:

Hon. Seth Low.	President Charles W. Eliot.
Prof. Francis G. Peabody.	Hon. Carroll D. Wright.
Dr. J. S. Billings.	Prof. Felix Adler.

Bishop E. G. Andrews.	Rev. Washington Gladden.
Prof. W. O. Atwater.	President Jas. MacAlister.
John Graham Brooks.	Rt. Rev. H. C. Potter.
Prof. Richard T. Ely.	Prof. W. M. Sloane.
Ex-President Daniel C. Gilman.	Dr. Wm. H. Welch.
Rev. Prof. Chas. A. Briggs.	

This Committee of Fifty has published four reports, viz:

The Liquir Problem in its Legislative Aspect, 1897.
Economic Aspects, etc., 1899.
Substitutes for the Saloon, 1901, and
Physiological Aspects of the Liquor Problem in 1903.

From the latter I wish to quote freely. A most interesting account may be found in it of the history of the attempt to pass a more stringent law in Massachusetts, the home state of Mrs. Hunt. After a trial for fourteen years of a law that I have referred to as the most lenient, the teachers, physicians and physiologists united to oppose with solid front the passage of a more stringent law. The report says: "The reasons for this opposition must be sought wholly in the *methods* rather than in the object of this 'scientific temperance' propaganda." In favor of the more stringent law appeared three delegates from the W. C. T. U., who supported their claims by:

1. "Dissertations on the evils of intemperance."
2. "Certifications of Mrs. Hunt's uprightness of character and nobility of intentions, coupled with broad insinuations that those who opposed her bill are in league with the liquor interests."
3. "Statements in regard to the beneficent effects of similar laws in other states proved by the good health of the troops during the late war."

The outcome of this controversy was that the more stringent bill was rejected, as well as that proposed by the educators, and the old law still stands. Among the objections enumerated by the educators of Massachusetts I find many with which we are all perfectly familiar.

I quote again: (1) "The specification by law of the amount of physiology and hygiene to be taught in the schools and the time to be devoted to it, a specification not made for any other subject; (2) The impossibility from scientific and pedagogic considerations of teaching physiology and pathology to children; (3) The irrationality of the idea that a frequent repetition of exaggerated statements develops character; (4) The danger of familiarizing the children of Massachusetts, who in the large majority of cases have temperate homes, with the methods and effects of evil conduct; (5) The preposterousness of the attempt to force teachers and school committees to act contrary to their convictions; (6) The failure of the supporters of Mrs. Hunt's bill to consult the teachers or to study the school conditions in a way which would make it possible for them to devise rational methods of instruction."

The report shows that eight of the twenty-three approved text-books are published anonymously. Mistakes and false statements have been repeated year after year, and even after the attention of Mrs. Hunt had

been called to some of them she replied that the books had been carefully examined by "eminent medical experts," and that the books had been found accurate.

Mr. Geo. H. Martin, agent of the Massachusetts State Board of Education, found by written tests of pupils in schools all over the state that, "whether one year or six are devoted to text-book work on the subject, makes practically no difference with the amount of the pupils' knowledge." He draws the following conclusions:

1. "Scientific temperance instruction is a misnomer."
2. "The result is meager out of proportion to the time spent."
3. "Many false impressions are left in the mind of the pupil."
4. "The strength of the universal sentiment that alcohol and tobacco are detrimental does not depend upon information acquired."
5. "Physiological details are not suited to young children."
6. "Exaggerated notions tend to create reaction in the light of after-knowledge."

Dr. G. W. Fitz sent letters of inquiry to 83 cities of Massachusetts, and secured replies from thousands of teachers. Seventy-two per cent considered the temperance instruction bad or of little value to 28 per cent excellent; while 98 per cent favored the bill known as the "Meyer bill," which was introduced to offset the Mrs. Hunt bill. Here are some of the opinions of Massachusetts teachers upon the approved texts:

1. "I think them generally untrue."
2. "They contain many errors and false statements."
3. "They should emphasize the normal rather than the abnormal."

From Wisconsin teachers:

1. "They are often false to facts."
2. "They appear to be written to be approved and indorsed to sell, and are really inferior books."
3. "They are as a rule weak books, 'doctored' and made to pander to the demands of *this society*."

From New York teachers:

1. "Most of them are pernicious scientifically and ethically."
2. "They defeat the very object for which the W. C. T. U. labors."
3. "Unscientific and in some cases ridiculous."

President Jordan says: "The scientific temperance movement has been judged thus far mainly by its motives which are good. It will come to be judged by its results, and these are bad."

Out of thirty physiologists consulted but one indorsed the so-called scientific instruction, and not one out of thirty foreign physiologists approved the books used.

Here are some quotations from letters of physiologists:

1. "This is an example of mistaken public benevolence which has nothing but the good motives of the originators to commend it, and which illustrates the danger of people meddling with things they do not understand."
2. "I place the lowest limit of age for the beginning of physiology at sixteen years."

3. "There is no propriety in teaching any form of physiology before the child has acquired some knowledge of chemistry and physics."

4. "I believe that the temperance cause is likely to be injured rather than advanced by such instruction."

5. "The temperance question in its essence is a moral and not a physiological question."

6. "It can be made apparently successful as a logical argument only by violating the truth in the premises laid down."

Here is an illustration of science out-scienced: A teacher was asked by Prof. Mendell how she would illustrate this statement from one of the approved books: "The liver may become inflamed and permanently changed in its tissues, producing the diseased condition called cirrhosis with the resulting dropsy of the abdomen." She replied she would "burn some alcohol to show its inflammable qualities. It produces inflammation."

I have during the last year questioned teachers from many parts of the country and find that the laws are very generally disregarded. In fact, the National Commissioner's Report shows that the number of pupils studying physiology has fallen off in ten years from one-third to one-fourth of the total.

The teachers of science will have to pursue one of three courses:

1. Teach the false doctrines and pursue the unpedagogical methods of the approved tests as required by law, or

2. Break the law by ignoring it, or

3. Unite to the end that the objectionable laws shall be repealed. There is no doubt in our minds which we shall do.

"The open letter published in School Science of last month shows the attitude of the W. C. T. U. toward our views. I note in passing that we are in distinguished company when we use the word "method," and very much the same results followed. One of the personal letters that accompanied the open letter says that "since the average human life has been lengthened four years by the teaching of physiology we think the *method* must be pretty good." If this is good logic I will put over against it this statement: The Annual Review of Foreign Commerce of the United States for the year ending June 30, 1903, shows that the number of gallons of wine and liquors consumed per capita in the United States between 1879 and 1903 increased from 8.66 to 19.48 per annum. That is, during the time that temperance physiology has been taught in the schools, the consumption of wines and liquors has more than doubled. Shall we conclude that it is due to temperance physiology? Would it not be just as logical to infer that human life has been lengthened four years by doubling the consumption of wines and alcoholic liquors?

We agree with the temperance workers about the terrible results of drunkenness and we commend the motives that lead them to untiring effort to suppress the consumption of alcoholic beverages; but we must forever condemn the attempt to teach truth by means of error. We must be given credit for having the same good motives they possess when we unite to oppose this whole method as prescribed to us by the laws of many of the states. This whole matter is a moral question, and not a scientific one.

The battle must be long and bitter, if our good friends insist, as they have thus far, in setting us down as a poor, deluded set of people animated by bad motives and in collusion with saloon interests.

The resolutions offered by the committee and adopted by the association were published in the last issue.

Let us see that the obnoxious *methods* are discussed at teachers' meetings. Let us call attention to the incubus that rests upon the public school system until the friends of truth and justice are aroused to action. And, finally, let us do all in our power to show that we approve of every fair means of teaching the immoral effects that result from the abuse of alcohol and narcotics in order that humanity may be released from the slavery of appetite.

J. E. Armstrong,
Chairman of Committee.

Report of Meetings.

THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.*

GENERAL SESSION.

The ninth annual session of the above-named organization was held in the Syracuse High School, December 27-29, 1904. The first meeting of the general session was called to order in the Physics lecture room by the retiring president, Irving P. Bishop, of the Buffalo Normal School. After referring to the important work accomplished by the committee on stimulants and narcotics, appointed in 1898, which has now completed its report, he introduced the president-elect, Ernest R. von Nardroff, of the Erasmus Hall High School, Brooklyn, N. Y.

Dr. von Nardroff, among other matters, spoke of a variety of research work, for which there is abundant opportunity in high schools, namely, the presentation of old truths in new and improved lights. This includes the devising and perfecting of apparatus to illustrate principles that are themselves already well known.

The first paper of the meeting was read by Prof. Wm. Hallock, of Columbia University, on "Science Study Parallel with Nature Study." The purpose of the paper was to show that if nature study can be taught to advantage in grammar schools, then physical science also is appropriate there.

Experiments with a magnet and iron filings are as well suited to arouse the interest and curiosity of children as is the study of an animal; of a toad, for example.

The directive force of the needle is no less interesting than the ability of the toad to jump, while stories of how this force has been of help to mariners would prove to be as instructive and interesting as those stories told about animals.

The description of leaves and twigs might be replaced by a study of

* The full proceedings of this organization will be published later by the Board of Regents at Albany, N. Y. This outline is made from notes taken during the progress of the meetings.

crystals, with experiments showing their formation on a piece of glass, thus leading to an examination of some of the beautiful crystals of snow.

Many topics taken up in nature study are too difficult, and should be preceded by the physical principles involved. Of this class are the functions of roots and leaves, and the circulation of the blood, involving osmosis, diffusion, absorption, evaporation, and other physical principles.

If apparatus is needed for science instruction, so is money spent on nature teaching. The time needed for experimenting in science is certainly not more than that needed for field trips.

Grade teachers can prepare themselves to teach Physics and Chemistry as well as Nature Study. In this preparation, they would have the advice and help of supervisors or of high school and college instructors. A series of leaflets like those in Nature Study might be prepared for teachers' use, naming the materials needed and describing all the details of the work.

This Science Study need not keep pupils away from the woods and fields, since it could be taken up in winter when the field excursions are dispensed with.

The next speaker was Prof. Ralph S. Tarr, of Cornell University, on the subject of "The Use of Lantern Slides in the Teaching of Physiography." He said that one of the difficulties met with by the teacher of Physical Geography is that most of the objects and phenomena which he teaches cannot be reproduced in the laboratory. To overcome this difficulty, there are five methods: (1) the field excursion, (2) an imitation of the phenomenon on a small scale in the laboratory, (3) the model, (4) the map, (5) the picture.

Of these, the last is becoming more and more useful. The most convenient form for the picture is the lantern slide, of which Professor Tarr himself has more than 5,000.

No pictures should be shown for show purposes, merely, but each should illustrate some truth in connection with the topic under discussion.

Professor Tarr operates his own lantern, which is placed at one side of the front of the room, with the screen opposite.

Slides are useful in connection with (a) recitations, (b) reviews, (c) laboratory work, (d) lectures. In some respects, slides are better than excursions, since different localities may be compared and points of similarity or of contrast clearly brought out. Questioning by the class is easier than in the field, and should be encouraged.

The development of various features of a landscape may be shown, as it were, in actual progress, by a succession of pictures properly selected, as, for example, the growth of a flood plain or the meandering of a river.

The lantern is important, also, in supplementing the excursion. Slides are made of the localities visited which help to strengthen the impression and assist the memory.

Slides greatly help the understanding of maps, especially of topographical maps, and of models. Many slides were shown to illustrate this use, as well as each of the other uses mentioned above; and, altogether, the great value of the slide in this study was impressively demonstrated.

An illustrated lecture was next delivered by Geo. F. Kunz, of New York, on "The Action of Ultra-violet Rays, Roentgen Rays, Radium Rays, and Other Influences on Mineral and Gem Substances." The phosphorescence and fluorescence of various minerals were shown, among the minerals being willemite, selenite, perdernite, colemanite, fluorite, willemite *b,* kunzite, and diamond. A crystal of kunzite was held between the poles of a static machine so that the full charge passed through the crystal, resulting in a brilliant phosphorescence which lasted for a number of minutes after it was removed from the source of excitration.

The ultra-violet lamp used was of the type known as the Görl-Piffard lamp, manufactured by the Waite and Bartlett Co., of New York, who also make the small hand-lamp (Kunz pattern), which can be attached direct to any electric light current not exceeding 120 volts. The coil used was also Waite and Bartlett's induction coil.

The U. S. Geological Survey and the U. S. Department of Mining Statistics have published reports describing some of the experiments of Dr. Kunz, which publications may be obtained on request.

The general session next met at the city hall, where a joint meeting with the associated principals of the state had been arranged.

First, a committee's report was read by Supt. Darwin L. Bardwell, of New York, on "The Preparation of Outlines in Science Subjects for the Regents' Syllabus, 1905." This report has been published in full in "The New York State Teacher," Ithaca, N. Y., issue of November last.

It recommends the following order for science studies in this state: First year, physiology (required by law) and botany, zoology or biology; second year, earth science, preferably physical geography; third year, physics (or, in large schools, chemistry); fourth year, chemistry or physics or astronomy, advanced botany, advanced zoology, or advanced earth study.

The report emphasizes the importance of (1) a thorough preparation for laboratory work, (2) requiring pupils to work independently of one another in the laboratory, (3) note-books being clearly, tersely and logically written, with drawings, (4) a proper division of time between the recitation, demonstration, laboratory work and quiz. A nature study course for grammar schools is advised, and two years of physics for those high schools that are prepared to do the work.

It was urged that science teachers be allowed more time for preparation for their classes.

Each science was then considered separately and at length, and suggestions made as to the subject-matter and character of the teaching. A year's work in physical geography is recommended as (a) being in line with the best thought of geographers, (b) most in conformity with the best text-books, (c) most closely in accord with the recommendations of the report of the committee on college entrance examinations of the National Educational Association, and (d) as adaptable to the requirements for college entrance as outlined by the college entrance examination board. From one-third to one-half the time should be given to laboratory and field work.

Twenty laboratory exercises in physiology are suggested.

Superintendent Bardwell's report was followed by another by Geo. M. Turner, of Buffalo, as chairman of a committee appointed by the Science Association to suggest changes in the regents' syllabus in physics and chemistry. The subject was discussed under the following heads:

(1) Topical outline, for recitation purposes. The aim of the recitation is to assist the understanding of the pupils and to develop thinking and individuality.

(2) The lecture and demonstrations. These are necessary, since many experiments are too difficult for the pupil to perform.

(3) Individual laboratory work. This part of the work is receiving more and more consideration.

(4) Problems. Important, but should be solved not for their training in mathematics, but only to make clear the scientific principles involved.

(5) The quiz; also important, as supplementing the laboratory work.

General suggestions are made, as follows:

(a) Great care should be exercised by the instructor in laboratory work to have the apparatus in good condition before the class begins work. This is for the purpose of saving time.

(b) No credit should be given for physics or chemistry unless taught in part by the laboratory method.

(c) A carefully kept laboratory note-book should be required. Diagrams of apparatus used should be frequently made.

(d) Credit for laboratory work should be on a credit basis, graded according to the quality and quantity of the work done.

(e) No credit should be given for less than a year's course.

(f) In schools well equipped, and having a course approved by the regents, examinations may well be left to the schools themselves.

Three courses in physics, to meet different conditions, are suggested, as follows:

1. A year's course, with forty required laboratory experiments, fifteen of which may be qualitative. In general, this course is like that outlined by the college entrance examination board, but differs from it in some particulars.

2. A year's course, to follow Course 1. This suggestion is in response to a growing sentiment in favor of two years of physics in the high school. The course was outlined in the regents' report of last year's meeting. It is for those pupils who show a special aptitude and liking for the study.

3. A year's course for schools less favorably equipped with apparatus, requiring at least thirty laboratory experiments, ten of which, only, may be in mechanics.

Outlines for Courses 1 and 3 were given. A list of apparatus was appended for Course 3, the cost of which need not be more than $8.50 per pupil for a class of six.

The outline for the course in chemistry differs considerably from that of the college entrance examination board. Objections to the latter were made: (1) that the order of topics is illogical, (2) that some of the

experiments are unsafe, and (3) that too many of them are quantitative in character.

The suggestions relating to chemistry were in the main similar to those for physics except that only two courses are outlined, corresponding to physics courses 1 and 3.

Prof. Chas. W. Hargitt, of Syracuse University, presented a paper, which, in his absence, was read by Professor Mace, on "The Place and Function of Biology in Secondary Education." It is impossible to give a correct idea of this eloquent presentation in a short resumé. A few of the topics developed can only be mentioned.

The problem of biological study is that of complete living; its purpose is the development of power in relation to man's environment. By it alone can we understand social phenomena. In the high school, at least one year should be given to the study of *living things.* Study plants and animals in their relation to one another—their likeness and differences.

As between no biology teaching and indifferent teaching, choose the former. Capable teachers are rare. Poets are born, not made; but teachers of biology must be both born and made. They must have souls responsive to the soul of nature, and must be trained to interpret nature's oracles. Biology is the revelation of the living world, in which all of us must remain from birth to death. The study aims to bring out the unity, correlation, and interdependence of the various forms of life. For example, consider the relation of germs to disease. By such studies, the length of life has been increased. Other problems are those of heredity and reproduction. These can be taught without any suggestion of impropriety, in connection with the simpler animals. The effects of narcotics can be incidentally demonstrated on a fish or frog.

The educational value of biology is in the development of the critical faculty, leading to a trained and sure common sense in regard to material things. The critical study of facts, and honest thinking, are necessary, and become a habit. To acquire these habits of mind is most important.

Biology is valuable as a culture study. The true idea of culture is that of breadth of view, largeness of soul, a general interest, liberality, and openness of mind, humility. These traits are developed by contemplation of the truths and beauties of nature. Biology leads up, finally, to the noblest possible study, that of man himself.

Discussion of the above reports and papers followed.

Mr. Howard Lyon, of the Oneonta Normal School, made a plea for the study of living plants and animals as opposed to dead ones. Of a class of thirty or forty pupils from high schools, he said, only two know a half-dozen of our common trees. He would omit a large part of the physiology of plants and animals and give more time to their life habits, environment, conditions of health, and industrial uses.

Prof. W. M. Smallwood, of Syracuse University, said that all classes of teachers represented at the holiday meetings here seemed to be of the same opinion, both as regards the importance of biological study and also as to when and how it should be taught. And yet biology does not seem to be an established science in high schools, at least it is not the same

science in different schools. Some note-books received at the university gave evidence of real work in the right spirit, while others were very deficient. Many teachers have not had the proper training to teach the subject. In that case it would be better not to attempt it. The teaching of a year's course in general biology in the first year would relieve the situation as regards physiology.

L. B. Gary, of Buffalo, spoke next, urging that a definite outline, shorter than the present one, be given in biology, so that teachers might know what was expected of them. The outline should, however, be long enough to allow of some choice of subjects. He would eliminate most of the experiments in dissection, especially those that show red blood.

The next speaker was Miss Burlingham, of Binghamton, who thought that some of the topics taken up in high schools should be taught in grammar schools, under the head of Nature Study. Dissection is necessary. In order to understand the structure of the animal it must be taken apart and the interior seen. In this way pupils learn to respect even the worm. Girls properly taught are not afraid of blood nor frogs nor mice. Dissection helps also in teaching evolution.

James E. Peabody, of New York, said that the correct view to take of this matter was that of the pupil, not that of the college professor nor of the scientist. Pupils are interested in life. In the first year of the high school, he would give many facts but not necessarily the relation between them. The interesting question is, What do plants and animals do? Therefore, give as much live work as possible. He would require biology of all pupils in the first year.

E. R. von Nardroff, of Brooklyn, said that one of the novel features of the reports was that relating to the second year course in physics. From his own experience he had learned that the cost for the second year course was less than for the first year. In the first place, much of the first year apparatus is used again in the second year. Secondly, it is not necessary to duplicate the apparatus used, since pupils, after a year's study, are able to begin anywhere in the course. An outfit for a class of thirty-five to forty can be obtained for $150.

The second year course, considering the ability of the pupils, is not more difficult than the first year's work. Topics already studied are elaborated, and additional experiments taken under each topic. Only the best pupils elect the study. To teach these is a pleasure. In fact, they nearly teach themselves.

In one year a mere smattering of physics, only, can be learned. The second year is as necessary as in any of the languages. As regards the syllabus as a whole, a list of topics is important in order to serve as a guide to the examiner. A general outline is of no value. It should be specific.

At the final meeting of the Association, held December 29, at the High School Building, the secretary, P. F. Piper, of Buffalo, reported that the financial condition of the Association was excellent, and that many new members had joined. The result of the election of officers was as follows:

President, A. P. Brigham, Colgate University; vice-president, Geo. M.

Turner, Buffalo; secretary and treasurer, J. Ellis Stannard, Owego. Syracuse was selected as the next place of meeting.

The last feature of the session was a lecture by Prof. J. S. Shearer, of Cornell University, on "The Development of Old Theories in Molecular Physics from Corpuscles to Electrons." This historical review was accompanied by a series of striking experiments illustrating various electric phenomena, and was throughout intensely interesting.

The simple ideas of the Greeks and Arabians were outlined and followed, down to Newton's conception of corpuscles or smaller and smaller particles, held together by forces greater, perhaps, than the forces attracting larger bodies. The objections to action at a distance, Faraday's idea of a continuous medium, and his great work on electrolysis; the growth of the kinetic theory of gases and of heat; the determination of the number of molecules in a cubic centimeter of gas, the size and mass of a molecule; the breaking up or dissociation of the molecules into ions; the discharge of gases in rarefied tubes and the relation between the degree of rarefaction and the kind of discharge; the velocity and mass of electrons, their production of heat, the deflection of them by a magnetic or electrostatic field, the amount of the charge carried by them, and also by the ions in an electrolyte; the methods of producing electrons by various great forces, such as an electrostatic strain, a high temperature, ultra-violet light, radioactive bodies; the discharge of an electroscope, the production of phosphorescence in willemite—these and other discoveries were reviewed and many of them illustrated by experiments.

Some time was then taken to show that electrons do not explain everything in molecular physics, as some have assumed. We cannot yet do without the electric wave. The necessity of tuning two systems to the proper wave-length was demonstrated by some experiments with a Tesla coil and oscillator. This was followed by an experiment showing the behavior of iron balls of different sizes in a strong magnetic field, in this way giving hints as to how the large positive nucleus of the atom may be surrounded by the minute negative electrons, and how the atoms in the molecule may unite or separate as the forces acting on them change. Finally, the method of transfer of electricity through a wire was suggested.

The value of such lectures as this, reviewing and illustrating a series of important recent discoveries, before a body of high school teachers, is undoubtedly very great.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION, PHYSICS AND CHEMISTRY SECTION.*

H. H. Denham, Syracuse, Chairman.

The meetings of this section were held in the physics lecture room of the Syracuse High School. The first subject taken up was "Physics Teaching in Germany," by F. L. Tufts, Columbia University. He said that very little laboratory work is done in Germany except at the universities. A few

* For a full report, see, later in the year, the Regents' Bulletin, Albany, N. Y.

schools, however, have recently introduced American laboratory methods, books and apparatus. One of these schools is in Hamburg, another in Giesen.

The average German student, however, on entering the university, is better prepared for the study of physics than the average American student. The reason for this is that the German is older, and is better prepared in mathematics. The university courses in Germany are about equal in scope and difficulty to ours.

The next speaker was Wm. J. Hancock, of Brooklyn, who did "Some Experiments in Physical Chemistry for the High School." Many of the laws and experiments of this new study, he said, are suitable for the high school. The first experiment to be shown would illustrate the fact that certain aqueous solutions conduct the electric current, while others do not. A pair of metal plates were immersed, in turn, in aqueous solutions of glycerine, sugar, an acid, a salt, etc., the plates being connected in series with an incandescent lamp and a source of current. The water used in making the solutions had been distilled. When the circuit was closed through the liquid, in some cases the lamp became bright, while in others it gave no indication of any current. The principle illustrated is that some substances in solution are dissociated into ions capable of carrying electricity, while other substances are dissociated to a much less extent.

The second experiment was given to show that the molecular conductivity of a solution increases with dilution. A tall rectangular trough, having its narrower sides made of wood, upon which were cemented strips of silver of uniform width, and the other sides being made of glass, was connected in series with a Daniell's cell and a lantern galvanometer. The cell was first filled with distilled water. When the circuit was closed there was no deflection of the galvanometer.

Twenty cubic centimeters of a fourfold normal solution of silver nitrate was then poured into the cell, and the deflection of the galvanometer needle noted. Further dilution brought out the fact that the first addition of water (about 100 c.c.) greatly increased the conductivity, while the last portion (about 600 c.c.) had little effect, thus indicating that practically all of the salt had been dissociated into ions before the last addition of water. For this experiment, the galvanometer was made of the proper degree of sensitiveness by placing a bar magnet under the needle.

The third experiment was to show that, while solutions of acids differ greatly from one another in conductivity, solutions of their respective potassium salts conduct the current to about the same extent. The apparatus was constructed in nearly the same way as that described by A. A. Noyes in the Journal of the American Chemical Society, November, 1900, page 736.

Four parallel circuits were made, each consisting of an electrolytic cell and an incandescent lamp. These were joined to a source of current of sufficient E. M. F. to light the lamps. Into each cell was poured one hundred cubic centimeters of distilled water. Then a given quantity of acid was put into each; into one sulphuric, into another nitric, etc.

The lamps showed different degrees of conductivity. Then the plates were adjusted until the lamps burned with nearly the same intensity (not too bright, since then the eye is less sensitive to differences in brightness). The tank containing hydrochloric acid was found to have its plates farthest apart, showing it to be the best conductor; that is, the most completely dissociated, and, hence, the strongest acid. The other acids were found to differ from one another, as shown by the different distances between their plates.

Next, these acids were changed into salts, by adding the proper solutions, after which the galvanometer showed an increased deflection; but it was about the same for one as another, showing that, while acids differ greatly from one another in conducting power, salts are much alike in this respect.

The fourth experiment was to show that the positive copper ions and the negative SO_4 ions of a copper sulphate solution travel with different velocities. Two horizontal copper electrodes were placed in a glass cell and insulated from each other at a distance of about one-quarter inch. Copper sulphate was poured into the cell and the image projected by a lantern on a screen. A current was passed and in a short time a white line was seen to develop at the cathode.

At the next session there was an exhibit of "Laboratory Experiments for Second Year Physics." L. V. Case, of Tarrytown, among other apparatus, showed a simple but effective clamp, of his own devising, for changing the length of a compound pendulum. The pendulum consisted of a heavy iron weight and a brass chain, so arranged that the pendulum had two component oscillations at right angles to one another. A record of the motion was made on a sheet of paper put under the weight, the marker consisting of a small glass tube filled with ink and placed vertically in a hole bored through the weight, the hole being slightly larger than the tube. The figures produced were clear and complete.

R. J. Kittredge, of Erie, Pa., showed the apparatus for experiments on vapor pressure and Kater's pendulum. A large number of experiments were shown by E. R. von Nardroff, F. J. Arnold, F. W. Huntington, and G. F. Wilder, all of the Erasmus Hall High School, Brooklyn, N. Y. Among these were experiments on the moment of inertia by use of rings, curve of exhaustion of an air pump, heat equivalent of the joule, mechanical equivalent of heat to 5 per cent, the compression of liquids.

Leora Sherwood had a class of pupils of the Syracuse High School in second year laboratory work, doing experiments, some of which were outlined by E. R. von Nardroff and others by O. C. Kenyon. Among these were Gauss's method of weighing, the law of transverse breaking strength of wooden strips, Smithsonian barometer, chromatic aberration of lens, self-induction by voltmeter method, and the frequency of an alternating current.

C. H. Harris, of Rochester, showed an experiment on the measurement of surface tension, and H. Cate, of Boston, exhibited an improved electroscope and a direct reading telescope.

A description of the above experiments will be given in the full report of the meeting.

The laboratory exhibit was followed by a paper by Wm. Hallock, of Columbia University, on the question, "Are We Justified in Demanding a Second Year in Physics in the High School?"

Prof. Hallock said that the phenomena studied in physics are so numerous and interesting that more time is needed for the subject than can be given in one year. The problem now is, what shall be left out? Very much important matter must be omitted.

The conditions in physics are different from those obtaining in other studies. In mathematics, for example, in which there is a series of natural steps, one may stop anywhere. But in physics a simple heading presents a host of experiments and applications. Physics covers nearly everything in practical life. There are heat, light, electricity, mechanics, sound. Some teachers have advocated the dropping of one or more of these general subjects, but this does not seem best.

It is a good pedagogical principle not to teach ultimate details at first, but to take the easy parts. This is done in Latin and geography. The same subjects are gone over a number of times, and each time something is added. So it should be in physics. In the grammar grades only the easiest parts ought to be taught. On taking up the subject again in the high school we should give a general outline, leaving for the second year a more systematic treatment of the more important and interesting details, the more difficult and accurate experiments.

In the next place, comparing physics with other studies, are we asking more than we are entitled to? Compare Latin, considering the value of the year's course in that study. In other languages, also, one year is acknowledged to be of little value. During the second and other later years of work in any study the knowledge already acquired is crystallized and real progress is made.

Again, is the second year deserved, judging by what physics teachers have already accomplished? Germany has judged us, and is introducing into her gymnasium our books, apparatus and methods.

At first we made a mistake. In our zeal for the general subject we laid stress on its informational value. We are now, in consequence, charged with not giving enough information. If the boy who has studied physics cannot explain the action of an electric motor running a fan he is thought to know little about the subject. The trouble is that one year is not enough to teach even the important everyday topics.

We are told, if we teach qualitatively only, that our subject has no training value; but if our methods are largely quantitative, we do not make the subject interesting. It is dull, monotonous.

We reply to the latter objection that first year Latin and Greek are not studied for the immediate enjoyment of it, but to prepare for what is coming later. If we are given more time for physics we can make as good use of it as is made in those subjects.

But, the question is asked, what will the colleges do about the second year of high school physics? My answer is, adapt themselves to it. The

best course for the high school is the best preparation for college. The business of the colleges will be to accept the course. In this state we have been greatly helped by the feeling that colleges should adapt themselves to the high schools as much as the high schools to the colleges. A college should receive any well-prepared boy, no matter what he has studied. Columbia agrees to do this.

In other words, the coördination will take care of itself. I am not troubled about pupils knowing too much physics when they come to college, provided that they really know what they have studied; and a second year of study will conduce to this end.

In the discussion which followed, C. N. Cobb, of the Regent's office, said that the only argument against a second year of physics was the lack of physical apparatus, most schools not being prepared to do the work. But that is no argument for those schools that are prepared. I believe, he said, in it thoroughly. A student will gain as much in second year physics as from almost anything else.

Principal Denham, of Syracuse, said that he was heartily in favor of the work where it could be done.

Prof. Hallock said that the cost of equipment decreases, after the first year is well provided for. Not so many pieces are needed for the second year. More time is given to each experiment. In some lines of original research $50 will keep a man at work for a year. In the second year also it is not necessary to duplicate apparatus, since each pupil can begin anywhere in the subject.

Messrs. Huntington and von Nardroff, of Brooklyn, next showed the operation of "A New and Simple Laboratory Apparatus for Accurately Rating a Tuning Fork's Vibrations." Mr. Huntington said that to the ordinary apparatus for this experiment there were many objections. The stylus does not work well, the glass does not remain in the same plane, the vibrations of the heavy weight do not continue long enough, the pendulum is too short to be accurately timed, and it is ahead of the stylus on the fork, while it should be opposite.

The new apparatus is made as follows: The fork is large, heavy, especially so at the base. It is made of bell metal, and firmly mounted. The prongs are accurately tuned to the same pitch. The ordinary laboratory wall pendulum or clock, having an electric contact, is used, the time of which can be obtained with great accuracy. An electro-magnet is mounted at the side of the fork, a pencil being so fastened to its armature that when the current passes, the pencil makes a dot on the paper at the side of the marker of the fork. The magnet and pendulum are in series with a battery. The marker for the pendulum is a small tube drawn to a point and provided with a drop of ink. The tube is slightly smaller than the hole through the fork. A roll of paper is held so that it may be drawn under the markers, being held in place by guides and having its track slightly raised at the place where the markers touch it.

One person draws out the paper, while another supplies the drop of ink, starts the pendulum and fork and closes the electric circuit. The best

way to set the fork in vibration is by pulling a stick from between its prongs.

The record made is a regular wavy line on the paper strip, which may be as long as desired. At intervals the pencil mark showing the time is seen by the side of the wavy line. With ordinary care the pupils of a class will agree in their results within one-fortieth of one per cent. With great care results can be obtained as accurate as one-hundredth of one per cent.

Prof. Pegram, of Columbia, now gave an illustrated lecture, "Experimental Demonstration of Some of the Phenomena of Radio Activity." The lecture was extremely interesting and accompanied with many new experiments. A special report of it has been promised.

(Reported by Associate Editor O. C. Kenyon.)

THE ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The Association met in Columbus, December 29 and 30, in connection with the Allied Educational Associations of Ohio. The sessions were held in Townshend Hall, Ohio State University. The program provided for one joint session and two sectional meetings on the afternoon of each day. In addition the Science Section held a morning session on Friday, December 30. The sessions were well attended, the interest good, the membership largely increased. SCHOOL SCIENCE AND MATHEMATICS was made the official organ, and in order that it may be sent to all members the council was directed to collect at the spring meeting 50 cents in addition to the regular dues. The members of the Association were given opportunity to study the laboratories and equipment of the university and were entertained at luncheon on Friday by the president and faculty.

In the absence of the president of the Association, President Chas. S. Howe, Case School of Applied Science, whose duties as general secretary of A. A. A. S. required his presence in Philadelphia, the vice-president, Prof. Alan Sanders, Hughes High School, Cincinnati, presided over the joint sessions and those of the Mathematical Section. Prof. Will G. Hormell, Ohio Wesleyan, Delaware, was made chairman of the Science Section. In his opening address, Professor Sanders emphasized the need of better text-books on geometry, pointing out particularly the defective application of the method of limits found in the usual texts.

Papers were read on the following topics:

JOINT SESSIONS.

"What Training in Mathematics is Desirable from the Standpoint of the Teacher of Physics?" by Miss Clara A. Davies, Doane Academy, Granville, and E. O. Weaver, Wittenberg College, Springfield.

"To What Extent is a Closer Correlation of the Different Branches of College Mathematics Desirable from the Teacher's Standpoint?" by W. H. Wilson, Wooster University, Wooster.

"Experimental Methods in Mathematics," by E. P. Thompson, Miami University, Oxford.

MATHEMATICAL SECTION.

"Should the College Entrance Requirements Recommended by the American Mathematical Society Be Adopted in Ohio?" by R. S. Pond, Marietta Academy, Marietta, and H. Hancock, University of Cincinnati, Cincinnati.

"What May Be Justly Assumed as to the Preparation of High School Graduates in Algebra, Both as to Quantity and Quality?" by J. D. Harlor, East High School, Columbus, and E. M. Mills, Ohio Normal College, Athens.

"What is a Good Outline for a Semester's Work in Required Algebra in the Freshman Year?" by F. Anderegg, Oberlin College, Oberlin.

"Is it Desirable to Introduce the Modern Treatment of Synthetic Geometry in the High School and College?" by M. E. Graber, Heidelberg University, Tiffin.

"What Should Be Covered in One Year's Elective Mathematics After the Freshman Required Mathematics: Should Such a Course Aim to Equip a Student for Applying Calculus in Scientific Work?" by S. S. Kellar, Wittenberg College, Springfield.

SCIENCE SECTION.

"Home-Made Apparatus in the Teaching of Physics," by A. D. Cole, Ohio State University, Columbus.

"Physics Previous to Physics," by J. A. Culler, Miami University, Oxford.

These papers were followed by a round-table discussion.

The two following papers were postponed to the April meeting:

"What Shall Be Done with the High School Pupil Who is Unable to Master Demonstrative Geometry: Shall Students Who Fail Only in Mathematics Be Permitted to Graduate from the High School?" by T. L. Feeney, Miami University, Oxford.

"How is Chemistry Best Taught to Beginners?" by C. F. Mabery, Case School of Applied Science, Cleveland. T. E. McKinney.

MEETING OF THE SCIENCE SECTION OF THE NEBRASKA TEACHERS' ASSOCIATION.

The Physical Science Section of the Nebraska State Teachers' Association recently held a most interesting and helpful session at Omaha. At the meeting reports of the Committees on "Apparatus," Status of Chemistry in Nebraska and Geography Teaching were distributed. The Science teachers of this state are working out new ideas and methods of instruction.

The officers for this year are:

President, Herbert Brownell, State Normal School, Peru; Secretary, H. A. Senter, Omaha High School, Omaha.

NEW PHYSICS CLUB.

The thirtieth regular meeting of the New Physics Club was held on Saturday, Jan. 28, 1905, in the Boys' High School, Brooklyn, President E. R. von Nardroff in the chair. After the Secretary's report, Mr. R. H. Hopkins presented the report of committee on current events. This consisted of a brief summary of facts which have been published during the last six months relating to the progress of investigation in physics and of other facts of interest to teachers of physics. Special reference was made to the so-called N-rays of Blondlot and to the work of Prof. Wood of Johns Hopkins in the same field. Prof. Wood not only failed to confirm the alleged discoveries of Prof. Blondlot, but became convinced that the French physicist was laboring under an illusion.

Mr. W. R. Pyle of the Morris High School exhibited and explained "An Apparatus for the Production and Measurement of Inaudible Sounds."

Mr. F. B. Spaulding of the Boys' High School exhibited and explained "A Simple Step-Down Transformer," and also "An Analogue of Electro-Static Induction." It is hoped that both of these interesting exhibits will be described in full in School Science and Mathematics.

Prof. Chas. S. Hastings of Yale University then gave a very interesting talk on "The History of Microscopes and How an Amateur Can Make Microscopic Objectives." Prof. Hastings explained the different steps in the improvement of the compound microscope, exhibited some objectives which he had made and some beautiful photographs of diatoms and other minute objects which he had taken with his own objectives. He urged members of the club to prepare their own objectives, a task which he said was not difficult up to a certain point, and offered to assist in carrying on the work. After a vote of thanks to Prof. Hastings the club adjourned.

Reported by R. H. Cornish.

BOOKS RECEIVED.

Pedagogues and Parents. By Ella Calisla Wilson. Henry Holt & Co.: New York.

How Nature Study Should be Taught. By Edward F. Bigelow, A.M., Ph.D., with an introduction by J. P. Gordy, Ph.D., LL.D., Professor of Pedagogy, New York University. Published by Hinds, Noble & Eldridge, 31-35 West Fifteenth Street, New York. $1.00.

BOOK REVIEWS.

ELEMENTS OF PLANE GEOMETRY.

Charles N. Schmall and Samuel M. Shack.

14x19 cms., IV. and 233 pages.

D. Van Nostrand Co.: New York. $1.25.

A really good excuse for offering to the school world a new text-book, on any subject, must be found in the facts that the market is not already well supplied in that particular line; that there is a real demand for the goods offered, or because the author believes that he has something new which it is his duty to make known. It is not clear that these reasons can be legitimately offered to justify the recent appear-

ance of the above book. The market is already pretty well supplied with text-books on this subject. This book seems to contain little that is new. It is no better and no poorer than many Plane Geometries already in the field. The publishers' part of the work is well done. The binding is substantial and attractive, the paper superior in quality, and the typography most excellent. It is the kind of book that makes a friend of the reader even before he begins to examine its contents. Many things may be said, too, in favor of the subject-matter. It is rich in original exercises which are calculated not only to test the pupil's knowledge of preceding theorems, but also to throw new light upon them. The suggestive method is used throughout. These are all features which commend it. But in an attempt to be simple or original, clearness of statement and accuracy of definition are sometimes sacrificed. "Two angles which have the same vertex and one side in the same line are called adjacent angles," is not a very accurate description of adjacent angles as that term has been commonly used nor a definite statement of the conception which the authors themselves had in mind. It appears later on that they wish to limit the meaning of the term to those adjacent angles which have their exterior sides in the same straight line; for we are told that when two adjacent angles are equal, each is called a right angle.

There are found, too, some little flaws in the logic of the book which might be a little puzzling to the mind of a beginner. To be told that "It is evident that all straight angles are equal," and then a few pages farther on, asked to prove that if one line is perpendicular to a second, the second is perpendicular to the first, when that term has been defined as the relation of the two lines forming the sides of two adjacent angles, does not seem to be quite consistent and is apt to be somewhat confusing to even older heads than those which are grappling for the first time with the mysteries of Euclid. E. E. Hill.

ELEMENTS OF COMPARATIVE ZOOLOGY.

J. S. Kingsley, S. D.

14x19 cms., X. and 437 pages. $1.20 net.

Henry Holt & Co., New York.

A second edition of Prof. Kingsley's *Comparative Zöology* has just been issued, the first edition appearing something like seven years ago. The work has been extensively revised and improved, and is now in many respects an admirable little introduction to this highly important department of zöological study. It combines the Manual and the Text in a single volume. Prominence is given to the vertebrate types, because, in the first place, it is among the back-boned forms that we find the richest fields of homology and because, as the author says in his preface to the new edition, "experience has shown that the work has been largely used as an introduction to, or preparation for, medical studies." The medical student is interested especially in the bodily architecture of his species and the architecture of the grasshopper and the coral is too aberrant or remote to shed much light on his chief subject.

This work, it may be said with confidence, is, notwithstanding its spirit and its many excellent qualities, a work that will never be used to any great extent in secondary schools. It is based on dissections, and the trend of high school methods is today firmly and irrevocably away from this method of teaching as a regular thing. Pupils do not like it. They object to it on both moral and æsthetic grounds; and we think their contention is well founded. Then, too, the multiplication of models, charts, skeletons and other teaching paraphernalia renders dissections largely unnecessary, except for the specialist, like the medical student, whose business it is to enter into anatomical details far beyond what is necessary or wise for high school students.

J. Howard Moore.

CHEMISTRY FOR SCHOOLS.

By Louis Sherman Davis, Associate Professor of Chemistry Indiana University.

19x13.5 cms., X. and 437 pages. $1.00.

Scott, Foresman & Co.

The aim of the author has been to follow the order of development of the science. With this thought uppermost, he has very skillfully knit together the various truths so that the relation between them seems natural and connected. A very casual observation shows one that the work is not a compilation of facts, but a very original development of this rather unsatisfactory high school subject.

The treatment of chemical equations and formulæ is is very unique, and at the same time striking. At first glance it seems that stoichiometry is the author's hobby and that he has overdone the matter. But a more careful reading shows the logic of his method. His exercises are just crowded to the brim with "think." They consist of just the kind of questions that will develop the pupil's imagination and increase his enthusiasm for the subject.

One phase of the book that the author has carried to extremes is his treatment of practical chemistry. A year is all too short to try to teach all the uses of chemistry in the arts. If he masters chemical nomenclature, chemical manipulation and theory, the first year of a high school course, that is enough. It is very difficult to leave out all these interesting data, but something must be sacrificed and it should be art rather than science.

The experiments are mixed with the text. This is a serious objection. He should, by all means, have inserted a list of apparatus and chemicals to help an inexperienced teacher. The drawings are excellent, and the laboratory directions simple and unambiguous. A valuable appendix has been added to the book.

All in all, the book will appeal to the average teacher. The student will find it interesting and clear. The exercises and experiments will stimulate his interest in the subject. We would recommend the book for all high schools, where time and equipment are limited.

Rockford (Ill.) High School. A. C. Norris.